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PAPERS ON ANTHROPOMETRY.

Reprinted from the *Publications of the American Statistical Association;*

TOGETHER WITH

THE GROWTH OF ST. LOUIS CHILDREN. *By William Townsend Porter, M.D.*

THE GROWTH OF CHILDREN. *By Dr. H. P. Bowditch.* (Reprint.)

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A PRELIMINARY REPORT ON ANTHROPOMETRY IN THE UNITED STATES.

By Edward Mussey Hartwell, Ph.D., M.D.,
Director of Physical Training in Public Schools of Boston, Massachusetts.

The writer has adopted the above title for this paper since his chief purpose, at this time, is to call attention to the number and variety of the publications which relate to anthropometry in the United States, without attempting a complete or critical analysis of any of them. It is also proper to note that the appended Provisional List includes several titles of books and articles which have been published in Europe by American writers, and a few titles of articles relating to anthropometry in America by European writers.

In this paper the term anthropometry is used in the sense originally attributed to it by Quetelet, which includes the measure of the different faculties of the human being; although anthropometrical study in the United States has been pursued, for the most part, for the sake of determining the physical proportions of the body and its parts.

Considered as a whole, the American literature on anthropometry consists largely of descriptive and tabulated reports of the results reached by individual observers in comparatively narrow and disconnected fields of investigation. A very considerable amount of material has been amassed, but much of it is so heterogeneous as to remind one of a heap of nuggets of crude ores of different kinds, which, to yield true metal, must needs be sorted, roasted, and refined. Nevertheless, in spite of some vagueness of aim and considerable diversity of methods, a sufficient amount of valuable material has been published in relation to the growth and development of children and adolescents to warrant an earnest and laborious attempt to sift, collate, and recast it in such wise as to make it available for the purposes of the vital statistician,

the biologist, the psycho-physicist, and even the routine educationist. It is clearly the part of wisdom to utilize the material at present in hand, partly in order that its actual value may be ascertained, and partly because a comprehensive and searching study of it would serve to indicate what problems should be attacked next, and to suggest the most hopeful means of attack in such problems.

That the study of anthropometrical problems has become more extensive and diversified recently is rendered evident by comparing the number and variety of the titles of works published since 1880, or even since 1890, with those published between 1850 and 1880. (See appended Provisional List.) It is noteworthy, moreover, that interest in the physiological and psycho-physical bearings of anthropometrical science is steadily increasing. [See the articles by Bolton (7), Bryan (12), Burnham (13), Gilbert (15), Porter (22), Scripture (26), and West (31) cited below].

As regards amount of statistical data and the discussion of theoretical questions, the weightiest contributions to anthropometrical science in America have been made in the department of Military Anthropometry by Messrs. Elliott (55), Gould (57), and Baxter (52). Next in rank, in the order named, are the departments of Anthropometry of School Children (see Bowditch, 8, 9, and 10; Peckham, 20 and 21; Porter, 22–25; and Boas, 5 and 6); and the Anthropometry of Students (see Hitchcock, 91–102; Sargent, 106–109; Enebuske, 88 and 89; and Wood, 113–117). The papers of Beyer (53), Enebuske (88 and 89), and Porter (22) give evidence of a growing tendency to attempt to correlate the results of anthropometrical investigations, and the teachings of physiology as to the development of functional power. In the field of criticism and discussion of methods the articles of Boas (34), Gulick (38), and Porter (47) mark a new and hopeful departure. Minot's paper (45) is a valuable contribution to the theory of growth. Spiess, of Frankfurt am Main, and Geissler and Ulitzsch, in Saxony, measured large

numbers of school children, in respect to height, in order to determine the normal dimensions of desks and seats to be used in school by the children in question. It would appear that no investigations of this sort, worthy of mention, have been made as yet in this country.

Dr. Bowditch's papers are of capital importance, by reason of the light they throw on the law of growth, and the significance of the physical changes incident to puberty. Their bearing upon school management has not been sufficiently recognized as yet by school authorities in this country. Dr. Bowditch is now generally credited with being the first to show that boys and girls have different rates of growth, as regards height and weight; and his observations and conclusions have been strikingly corroborated by Peckham, Porter, and West in the United States, and by the investigations of a Royal Commission in Denmark, by Roberts in England, Pagliani in Italy, Erismann in Russia, Geissler and Ulitzsch in Saxony, and by Axel Key in Sweden.

The writer, who is at present engaged in making a comparative study of mortality and growth rates, finds that there is a striking relation between the death rates of Boston boys and girls and their respective rates of growth, as determined by Bowditch. That is to say, the death rates of Boston boys are lowest during the period of their most rapid growth, and the death rates of Boston girls are lowest during their period of most rapid growth. He also finds that a similar relation exists between the death and growth rates of Swedish boys and girls. The results of the writer's investigations touching this question will be published shortly in the *Quarterly Publications of the American Statistical Association.*

The use of anthropometry as a means for guiding and testing procedures in physical training is becoming general in the leading colleges for men and women, and in a few secondary and special schools, and in the Y. M. C. A. Herein is found one of the most characteristic developments of anthropometry in America. In this connection, special mention

should be made of the life size "anthropometric statues" exhibited by Dr. Sargent in the Anthropological Department of the Columbian Exposition, since they constitute a unique and highly interesting contribution to anthropometry. They are intended to represent the bodily proportions and conformation of the typical college man and college woman, and are based on extensive unpublished data belonging to Dr. Sargent. The Bertillon anthropometrical system, for the identification of criminals, has been adopted by a few penal institutions. Extensive anthropometrical investigations have recently been made upon American Indians under the supervision of Dr. Franz Boas. The results of Dr. Boas's studies remain to be published. The amount of undigested and unpublished material in military, prison, school, and college anthropometry is now very extensive, and increases yearly.

Hitherto American anthropometrists, as a rule, have worked too much apart from one another, along short lines, and within comparatively narrow limits. It is time to attempt to bring about a closer organization, one that shall conduce to unity of purpose and intelligent coöperation in the field of investigation, and to the adoption of the most approved scientific methods of recording, collating, and publishing the results of such investigations. Such an organization should also seek to keep heartily and thoroughly in touch with the anthropometrists of Europe. It is to be hoped that the recent establishment of special committees on anthropometry by the International Statistical Institute, and of the American Statistical Association, respectively, will tend to promote a more vigorous and intelligent prosecution of anthropometrical studies on both sides of the Atlantic.

PROVISIONAL LIST OF WORKS —ARTICLES, BOOKS, AND TABLES — RELATING TO ANTHROPOMETRY IN THE UNITED STATES, INCLUDING 117 TITLES, ARRANGED IN CLASSES I–VI.

Class I, Nos. 1–3, titles relating to Art.
Class II, Nos. 4–33, titles relating to Anthropometry of Children.
Class III, Nos. 34–51, titles relating to Methods in Anthropometry.
Class IV, Nos. 52–58, titles relating to Military and Naval Anthropometry.
Class V, Nos. 59–85, titles relating to Miscellaneous Topics in Anthropometry.
Class VI, Nos. 86–117, titles relating to Anthropometry of Students.

ANALYSIS OF TITLES ACCORDING TO DATE OF PUBLICATION AND CLASS OF SUBJECT.

	1. Art.	2. Children.	3. Methods.	4. Military.	5. Miscellaneous.	6. Students.	Total.
Period 1850–60	0	0	0	1	2	0	3
Period 1860–70	1	0	0	2	4	1	8
Period 1870–80	1	3	0	1	2	0	7
Period 1880–90	1	8	8	1	8	10	36
Period 1890–94	0	19	10	2	11	21	63
Sum	3	30	18	7	27	32	117

CLASS I. TITLES RELATING TO ART.

1. ALLEN, H. *An Analysis of the Life-Form in Art.* Philadelphia, 1875. 4to.
2. FLETCHER, R. *Human Proportion in Art and Anthropometry.* A lecture delivered at the National Museum, Washington, D. C. Cambridge, 1883. M. King. 37 p. 4 pl. 8vo.
3. STORY, W. W. *The Proportions of the Human Figure, According to a New Canon, for Practical Use: with a Critical Notice of the Canon of Polycletus, and of the Principal Ancient and Modern Systems.* London, 1866. 8vo.

CLASS II. TITLES RELATING TO ANTHROPOMETRY OF CHILDREN.

4. ABBOTT, S. W. *The Evidence of Still-Birth.* Transactions of Massachusetts Medico-Legal Society. I. 56. Boston, 1879. Relates to length and weight of infants at birth.
5. BOAS, F. *Anthropological Investigations in Schools.* Pedagogical Seminary, Worcester, Mass., 1891. I. 225–228. Also in *Science*, New York, 1891. Vol. xvii, 351–352.
6. ——*The Growth of Children.* Science. New York, 1892. Vol. xix, 256; 281–282; xx, 351–352.
7. BOLTON, T. L. *The Growth of Memory in School Children.* American Journal of Psychology. 1892. Vol. iv, 189–192; 362–380.
8. BOWDITCH, H. P. *The Growth of Children.* Report of Board of Health of Massachusetts. Boston, 1877. Vol. viii. 51 p., 10 tables.
9. ——*The Growth of Children: a Supplementary Investigation, with Suggestions in Regard to Methods of Research.* Report of Board of Health of Massachusetts. Boston, 1879. Vol. x. 33–62. 11 pl.
10. ——*The Growth of Children. Studied by Galton's Method of Percentile Grades.* Report of Board of Health of Massachusetts, 1889–90. Boston, 1891. Vol. xxii. 479–522.
11. ——*The Relation between Growth and Disease.* Reprinted from Transactions of the American Medical Association. Philadelphia, 1881. 9 p.
12. BRYAN, W. L. *On the Development of Voluntary Motor Ability.* American Journal of Psychology. Worcester, 1892. Vol. v. 125–204. 3 charts.
13. BURNHAM, WM. H. *A Scheme of Classification for Child-Study.* Pedagogical Seminary. Worcester, Mass., 1893. Vol. ii. 191–198.
14. CHAILLE, S. E. *Infants: their Chronological Progress.* New Orleans Medical and Surgical Journal, 1886–87. N. S. Vol. xiv. 893–912. Also reprint.
15. GILBERT. *Experiments on the Musical Sensitiveness of School Children.* Studies from the Yale Psychological Laboratory. 1892–93. 80–87.
16. GREENWOOD, J. M. *Heights and Weights of Children.* American Public Health Association Report, 1891. Concord, N. H., 1892. Vol. xvii. 199–204.

17. HINDS, CLARA BLISS. *Child Growth.* Reprint of paper before Women's Anthropological Society of Washington. Washington, D. C., 1886. 8 p.

18. MOON, S. B. *Measurements of the Boys of the McDonogh School for the Years 1888–1891: arranged in Order of Height, Summed and Averaged. Also a Percentile Table for 115 Boys 13–14 Years of Age.* McDonogh, Maryland, 1892. 46 p. 4to.

19. MORSE, W. H. *The Baby's Growth.* Virginia Medical Monthly. Richmond, 1886–87. Vol. xiii. 392–395.

20. PECKHAM, GEORGE W. *The Growth of Children.* Report Wisconsin Board of Health, 1881. Madison, 1882. Vol. vi. 28–73. 2 pl. 12 diag.

21. ——*Various Observations on Growth.* Ibid, 1882. Madison, 1883. Vol. vii, 185–188.

22. PORTER, W. T. *The Growth of Saint Louis Children.* Transactions of the Academy of Science of St. Louis, 1894. In press.

23. ——*The Physical Basis of Precocity and Dullness.* Transactions of the Academy of Science of St. Louis. St. Louis, 1893. Vol. vi. 161–181.

24. ——*The Relation between the Growth of Children and their Deviation from the Physical Type of their Sex and Age.* Transactions of the Academy of Science of St. Louis. St. Louis, 1893. Vol. vi. 233–250. 8 tables. 1 diag.

25. ——*Ueber Untersuchungen der Schulkinder auf die Physischen Grundlagen ihrer geistigen Entwickelung.* Read in Berliner Gesellschaft für Anthropologie, Ethnologie, und Urgeschichte, 15 July, 1893. Zeitschrift für Ethnologie. Berlin, 1894. 337–354.

26. SCRIPTURE, E. W. *Tests on School Children.* Educational Review. New York, 1893. Vol. I. 52–61.

27. STOCKTON-HOUGH, J. *Statistics Relating to Seven Hundred Births (White) Occurring in the Philadelphia Hospital, between 1865 and 1872.* Philadelphia Medical Times, 1885–86. Vol. xvi. 92–94.

28. WEST, G. M. *Anthropometrische Untersuchungen über die Schulkinder in Worcester, Mass.* Archiv für Anthropologie. Braunschweig, July, 1893. Vol. xxii. 13–48; 23 tables; 5 diag.

29. ——*The Anthropometry of American School Children.* Proceedings of the International Congress. Chicago, 1893. In press.

30. ——*The Anthropometry of Japanese School Children.* In press.
31. ——*Eye-Tests on School Children.* American Journal of Psychology. 1892. Vol. iv. 595–596.
32. ——*The Growth of the Breadth of the Face.* Science. New York, 1891. Vol. xviii. 10–11.
33. ——*Worcester (Mass.) School Children; the Growth of the Body, Head, and Face.* Science. New York, 1893. Vol. xxi. 2–4.

CLASS III. TITLES RELATING TO METHODS IN ANTHROPOMETRY.

34. BOAS, F. *The Theory of Anthropometrical Statistics.* Paper read September 16, 1893, before the International Statistical Institute, at Chicago. Quarterly Publications of the American Statistical Association. Boston, Dec., 1893.
35. GALTON, FRANCIS. *Useful Anthropometry.* Proceedings of the American Association for Advancement of Physical Education, 1891. Ithaca, N. Y., 1891. Vol. vi. 51–57.
36. GIHON, A. L. *Physical Measurements.* Wood's Reference Hand-book of the Medical Sciences. New York, 1887. Vol. v. 667–673.
37. GREENLEAF'S, DR., *New Table of Physical Proportions.* Baltimore Underwriter. 1890. Vol. xliii. 303.
38. GULICK, L. *Manual for Physical Measurements, in Connection with the Y. M. C. Association Gymnasium Records.* New York, 1892.
39. ——*The Value of Percentile Grades.* Quarterly Publications of the American Statistical Association. Boston, 1893. N. S. Nos. 21, 22. 321–331.
40. HITCHCOCK, E., Jr. *Physical Measurements, Fallacies, and Errors.* Proceedings American Association for Advancement of Physical Education, 1887. Brooklyn, N. Y., 1887. Vol. iii. 35–42.
41. HOLGATE, T. H. *An Instrument for Measuring the Lower Extremities Correctly.* Medical Record. New York, 1881. Vol. xx. 164.
42. HURD, KATE C. *Some of Galton's Tests Concerning the Origin of Human Faculty.* Proceedings American Association for Advancement of Physical Education, 1891. Ithaca, N. Y., 1891. Vol. vi. 80–96.

43. JACKSON, W. A. J., JR. *Graphic Methods in Anthropometry.* Physical Education. Springfield, Mass., 1893. Vol. ii. 89–94.

44. KELLOGG, J. H. *A New Dynamometer for Use in Anthropometry.* Battle Creek, Michigan, 1893. No imprint.

45. MINOT, C. S. *Growth.* Reference Hand-book of the Medical Sciences. New York, 1886. Vol. iii. 394–400.

46. MULLER, G. *Alphonse Bertillon's Method for the Identification of Criminals.* Anthropometric Identifications. Adopted by the Wardens' Association for the Registration of Criminals, at their meeting in Toronto, September, 1887. Instructions for taking measurements and descriptions. Translated from the French by Gallus Muller, Clerk of the Illinois State Penitentiary. Joliet, Ill., 1887. 84 p. 8vo.

47. PORTER, W. T. *On the Application to Individual School Children of the Means Derived from Anthropological Measurements by the Generalizing Method.* Paper read September 16, 1893, before the International Statistical Institute, at Chicago. Quarterly Publications of the American Statistical Association. Boston, Dec., 1893.

48. SARGENT, D. A. *Report on Anthropometric Measurements. A Schedule of Measurements with Directions for Making Them.* Presented by a Committee of the A. A. A. P. E., through its Chairman, Dr. Sargent, and adopted by the Association, November 26, 1886. Proceedings American Association for Advancement of Physical Education, 1886. Brooklyn, N. Y., 1886. Vol. ii. 6–15.

49. ——*Anthropometric Apparatus, with Directions for Measuring and Testing the Principal Physical Characteristics of the Human Body.* Cambridge, Mass., 1887. 8vo.

50. SEAVER, J. W. *Anthropometry and Physical Examination. For Practical Use in Connection with Gymnasium Work and Physical Education.* New Haven, 1890. 127 p.

51. SWAIN, F. *Anthropometric Measurements.* Proceedings American Association for Advancement of Physical Education, 1887. Brooklyn, N. Y., 1887. Vol. iii. 43–50.

CLASS IV. TITLES RELATING TO MILITARY AND NAVAL ANTHROPOMETRY.

52. BAXTER, J. H. *Statistics, Medical and Anthropological, of the Provost-Marshal-General's Bureau, Derived from Records of the*

Examination for the Military Service in the Armies of the United States During the Late War of the Rebellion of over a Million Recruits, Drafted Men, Substitutes, and Enrolled Men. Compiled under direction of the Secretary of War. 2 vols. 4to. Washington, D. C., 1875.

53. BEYER, H. G. *Observations on Normal Growth and Development of the Human Body Under Systematized Exercise.* Report of Surgeon-General of the U. S. Navy, 1893. Washington, D. C., 1893. 141–160. 16 tables in text.

54. COOLIDGE, R. H. *Statistical Report on the Sickness and Mortality of the Army of the United States, Compiled from the Records of the Surgeon-General's Office, from January, 1839, to January, 1855.* Washington, D. C., 1856.

55. ELLIOTT, E. B. *On the Military Statistics of the United States of America.* Printed for the United States Sanitary Commission. Berlin, 1863. 44 p. 2 pl. 4to.

56. GIHON, A. L. *A Study of Adolescent Growth, Based on the Physical Examination of 6129 Naval Cadets and Candidates for Appointment as Cadets, and 2058 Naval Apprentices.* Report of the Surgeon-General United States Navy. Washington, D. C., 1880. 15–44.

57. GOULD, B. A. *Investigations in the Military and Anthropological Statistics of American Soldiers.* U. S. Sanitary Commission. New York, 1869. 655 p. 8vo.

58. STERNBERG, GEORGE M. *Physique of Accepted Recruits and Re-enlisted Men (U. S. Army), 1892.* Report of the Surgeon-General of the Army to the Secretary of War, 1893. Washington, D. C., 1893. 20; 226–227.

Table XXV gives average height, weight, and chest measure of 9585 recruits (8555 white, 833 colored, 197 Indian).

CLASS V. TITLES RELATING TO MISCELLANEOUS TOPICS IN ANTHROPOMETRY.

59. BEARD, G. M. *English and American Physique.* North American Review. New York, 1879. Cxxxix. 588–603.

60. BOAS, F. *Physical Characteristics of the Indians of the North Pacific Coast.* American Anthropologist. 1891. Vol. iv. 25–32.

61. BOWDITCH, H. P. *On the Collection of Data at Autopsies.* A report presented to the Massachusetts Medico-Legal Society, February 1, 1882. Reprint. No imprint.

62. ——*The Physique of Women in Massachusetts.* Report of Board of Health of Massachusetts, 1889. Boston, 1890. Vol. xxi. 287–304. 1 table. Also reprint.

63. BRADFORD, E. H. *The Effect of Recumbency on the Length of the Spine.* Boston Medical and Surgical Journal. 1883. Vol. cix. 245.

64. BRINTON, D. G. *External Mensuration of the Human Subject.* Medical and Surgical Reporter. Philadelphia, 1869. Vol. xx. 1–2.

65. CORDEIRA, F. J. B. *A Contribution to Anthropometry.* New York Medical Journal. New York, 1887.

66. DICKSON, S. H. *Statistics of Height and Weight in the South.* Charleston Medical Journal and Review, 1857. Vol. xii. 607–613.

67. ——*Some Additional Statistics of Height and Weight.* Ibid. 1858. Vol. xiii. 494–506.

68. ——*Statistics of Height and Weight.* American Journal of Medical Sciences. Philadelphia, 1866. N. S. Vol. lii. 373–380.

69. DUN, W. A. *The Police Standard of Cincinnati; with some Statistics Compiled from the First Thousand Examinations of Applicants.* Cincinnati Lancet-Clinic, 1887. N. S. Vol. xviii. 131–135; 767–769.

70. FRENCH, M. S. *Report of the Physical Examination of Men upon the Police Force of Philadelphia, and those who were Applicants for Appointment.* Philadelphia, 1885.

71. HARTWELL, EDWARD M. *Preliminary Report on Anthropometry in the United States. With Provisional List of Works Relating to Anthropometry in the United States.* Paper read before the International Statistical Institute at Chicago, September 16, 1893. Quarterly Publications of the American Statistical Association. Boston, Dec., 1893.

72. HURD, KATE C. *On Anthropometry.* Times and Register. New York and Philadelphia, 1890. Vol. vii. 506–511.

73. KELLOGG, J. H. *Outline Studies of the Human Figure, Comprising 118 Figures which Embody the Results of Several Thousand Observations, Embracing Studies of a Number of Different Civilized and Uncivilized Races.* Modern Medicine Publishing Co. Chicago, London, and Battle Creek, Mich., 1893.

74. ——*Physical Chart, Arranged from Results Obtained in Testing the Strength of Individual Groups of Muscles in 200 Men, Ages 18–30 Years, by Means of Dr. Kellogg's Mercurial Dynamometer.* Battle Creek, Mich., 1893.

75. ——*Physical Chart, Arranged from the Results Obtained in Testing the Strength of the Individual Groups of Muscles in 600 Men by Means of a Universal Mercurial Dynamometer.* Battle Creek, Mich., 1893.

76. ——*Physical Chart, Arranged from the Results Obtained from Testing the Strength of the Individual Groups of Muscles in 600 Women by Means of a Universal Mercurial Dynamometer.* Battle Creek, Mich., 1893.

77. ——*Table of Strength Measurements, Arranged from the Measurements of 100 Adult Women.* Battle Creek, Mich., 1891.

78. ——*Table of Strength Measurements, Arranged from the Measurements of 100 Adult Men.* Battle Creek, Mich., 1891.

79. LEE, C. A. *A Table Showing the Physical Characteristics of the Members of the United States Senate.* First Session 39th Congress. Buffalo Medical and Surgical Journal, 1866–67. Vol. vi. 390–396.

80. MORRIS, M. *Biometry: its Relation to the Practice of Medicine.* Medical Record. New York, 1875. Vol. x. 481–486.

81. RUSCHENBERGER, W. S. W. *Contributions to the Statistics of Human Growth.* American Journal of Medical Sciences. Philadelphia, 1867. N. S. Vol. liii. 67–70.

82. SARGENT, D. A. *The Physical Development of Women.* Scribner's Magazine, February, 1889. Vol. v. 172–185.

83. TITCHENER, E. B. *Anthropometry and Experimental Psychology.* Philosophical Review. Boston, New York, and Chicago, 1893. Vol. ii. 187–192.

84. WEST, G. M. *The Anthropometry of North American Mulattoes.* In press.

85. WILKINS, W. W. *Comparative Measurements of the Chest.* Transactions of New Hampshire Medical Society. Manchester, N. H., 1886. 125–130.

CLASS VI. TITLES RELATING TO ANTHROPOMETRY OF STUDENTS.

86. ALLEN, N. *Physical Culture in Amherst College.* 8vo. Lowell, 1869.

87. ANDERSON, W. G. *Students in Gymnasium.* Adelphian. Brooklyn, 1885. Vol. v. No. 1. 10.

88. ENEBUSKE, CLAËS J. *An Anthropometrical Study of the Effects of Gymnastic Training on American Women.* Paper read September 16, 1893, before the International Statistical Institute, at Chicago. Quarterly Publications of the American Statistical Association. Boston, Dec., 1893.

89. ——*Some Measurable Results of Swedish Pedagogical Gymnastics.* Proceedings of American Association for Advancement of Physical Education, 1892. Springfield, Mass., 1893. Vol. vii. 207–235. 8 tables in text.

90. HANNA, DELPHINE. *Anthropometric Tables, Compiled from the Measurements of 1600 Women (Oberlin Students), Department of Physical Training Oberlin College.* Oberlin, Ohio, 1893. No imprint.

91. HITCHCOCK, E. *An Anthropometric Study of the Students of Amherst College, Constructed upon Bodily Stature as the Basis of Comparison.* Second edition. 1893. No imprint. Contained also in No. 102.

92. ——*Average and Mean Anthropometric Data of Amherst College Students.* 1888. 8vo. No imprint.

93. ——*Comparative Study of Measurements of Male and Female Students at Amherst, Mount Holyoke, and Wellesley Colleges, U. S. A.* Physique. London, 1891. Vol. i. 90–94. Also in Proceedings of American Association for Advancement of Physical Education. Ithaca, N. Y., 1891. Vol. vi. 37–42.

94. ——*The Distribution of Physical Measurements Shown in the Different Years of College Life.* Amherst College. 1892. No imprint.

95. ——*The Gain in Physical Strength of College Students.* Two tables. Amherst, 1892. No imprint.

96. ——*Physical Growth of Amherst Students. Gain Between Freshman and Senior Years.* 1892. No imprint.

97. ——*The Results of Anthropometry as Derived from the Measurements of the Students in Amherst College.* Amherst, Mass., 1892. 7 p. 6 tables. 8vo.

98. ——*Summary of Anthropometrical Studies of the Students of Amherst College.* Paper read September 16, 1893, before the

International Statistical Institute, at Chicago. Quarterly Publications of the American Statistical Association. Boston, Dec., 1893.

99. HITCHCOCK, E., JR. *A Synoptic Exhibit of 15,000 Physical Examinations.* Made on male college students. Ithaca, N. Y., 1890.

For summary of averages shown graphically in above table see Proceedings of American Association for Advancement of Physical Education, 1890. Ithaca, N. Y., 1890. Vol. v. 5.

100. ——*Report on Physical Culture to the President of Cornell University.* Contains two tables showing the standing in scholarship of Cornell oarsmen, base-ball men, and members of athletic teams; and seven synoptic anthropometric charts. See Appendix II. Annual Report of the President of Cornell University for 1887–88. Ithaca, N. Y., 1888. 111–125.

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REMARKS ON THE THEORY OF ANTHROPOMETRY.

By Franz Boas, Ph.D.

The theory of anthropometric statistics is based largely upon Quetelet's investigations, who endeavored to prove that the distribution of anthropometric data follows the law of chance. Some attempts to develop the theory further have been made by Stieda and Ihering and by Francis Galton. The former emphasized the introduction of the average variation of measurements into the consideration of the subject, the latter developed what has become known as the method of percentile grades. Stieda was also the first to express a doubt as to the general applicability of the law of chance.

The anthropometric characteristics of a group of people are treated in various ways. Some authors consider the average of the measurements the most valuable result; others prefer to compute the mean value, which is, more properly speaking, the probable value, as it is computed as that value above and below which fifty per cent of the whole series are found; still others compute the most frequent value. The followers of Francis Galton compute the mean value and the points representing various percentile grades, *i. e.*, points below which ten per cent, twenty per cent, thirty per cent, and so forth, of the total series are found. Anthropologists who study the physical characteristics of races use mostly the method of seriation. They give the percentage of cases of the series which fall between certain limits. Still another method which is frequently applied consists in the comparison of those percentages of the series which lie above or below a certain limit.

We will examine the merits of these methods. Whenever

the distribution of measurements follows the laws of chance the average may be considered the type represented by the series. In this case the average, the probable value, and the most frequent value will be identical, provided the series of observations is sufficiently large. In practice they will naturally always show slight differences. In these cases the average must be used, not the probable or the most frequent value, because the first named can be determined with greater accuracy than the others. When a limited number of observations are given, and the mean error of the average, of the probable value, and of the most frequent value are computed, it is found that the mean error of the average is smaller than that of the probable value; the mean error of the latter is, in turn, smaller than that of the most frequent value. For this reason the probable value, or, as it is often called, the mean value, or the fifty percentile grade, must not be used for the purpose of describing the type of a series of measurements which are distributed according to the laws of chance.

When the distribution of cases does not correspond to the laws of chance, neither the average, nor the probable value, nor the most frequent value can be utilized without a previous theoretical treatment of the curve representing the laws of distribution. Based on Quetelet's statements, it has generally been assumed that all anthropometric measurements are distributed according to the laws of chance, and that the curves will approach the theoretical curve the more closely the greater the number of cases that is embodied in the series. I believe that Stieda was the first to intimate that deviations from the law may occur, although he does not follow out this suggestion. A. and J. Bertillon have proved that such deviations occur. Later on, Bowditch has shown that the curves showing the distribution of statures and weights of children do not follow the laws of chance. He shows this by pointing out the fact that during the period of growth a constant difference exists between the average and probable

values. Galton also paid some attention to this subject, and Dr. Gulick mentioned it in a recent paper. Glancing over the curves representing large series of measurements, it strikes me that they conform to the laws of chance only in a general way, and that considerable deviations are quite frequent. It is necessary to consider the biological laws underlying the phenomena under consideration. Assuming that there is a uniform ancestral type in a certain district, and that the conditions of life remain stable, we may expect that the people representing its offspring will be grouped around the type according to the laws of chance. Assuming, however, that there were two distinct ancestral types in adjoining districts, and that these types intermingled, we cannot foretell what the distribution of forms among the offspring will be. It may be that they represent an intermediate type between the parental forms. In this case we might expect to find them distributed according to the laws of chance. But it may also be that we find them to have a tendency to reproduce one or the other ancestral type, either pure or slightly modified. In this case the resulting curve would not conform to the laws of chance, and would show an entirely different character. There is considerable evidence that the laws of inheritance are such that there exists a tendency of reproducing ancestral traits, not of producing new intermediate traits. Therefore, we may be prepared to find considerable deviations from the laws of chance. It is clear that, if intermixture does not result in producing an intermediate type, an attempt to express the type by means of an average of the existing forms will have no meaning whatever. The probable value would have just as little meaning. If the two parental forms were entirely distinct and reproduced without change, the most frequent values might have a meaning, as the two forms would occur most frequently. This, however, would depend upon many conditions favorable to such a result: the proportion of the two elements would have to be nearly equal, their difference

great, and each form must have a limited amount of variability only. A concrete case of this kind is found in the anthropometry of the half-blood race of Indian and white parentage. Generally speaking, the ancestry of a people will be such that a number of forms which do not differ very much among themselves enter into its composition. The greater the number of forms, the nearer the curve of measurements will conform to a probability curve; but, nevertheless, it must be borne in mind that the mixture may be such that constant deviations from such a curve are found which are not due to accident. Our conclusion from these considerations is that anthropometric measurements do not, as a rule, follow the laws of chance, and that a careful examination of the curves is necessary in each case. We cannot expect that in all cases a classification of the material will lead to curves which follow the laws of chance more closely, as the laws of heredity are such that they do not necessitate an arrangement of this character. These facts must make us very careful in the use of the average considered as the type of a series. It will be necessary to investigate each series in order to ascertain if there are any deviations from the law of chance which seem to be due to constant causes, not to accident.

Besides these biological considerations, we must consider a number of other factors which may cause deviations from the probability curve. If a series of measurements is distributed according to the laws of chance, and the measurements of the whole series are changing, deviations will occur whenever the rate of change is not uniform. Such changes occur during the period of growth, and this is the cause of the asymmetry of distribution of measurements of children to which Dr. Bowditch called attention. Similar changes may occur when the conditions of life of a community are changing, or when one form is gaining preponderance over another form. In all such cases the computation of the average, of the mean, and of the most frequent value have no

meaning. The cause and character of the asymmetry of the curve must be determined, and a mathematical treatment must be applied which takes the asymmetry into consideration. It is not necessary to elaborate the theory of treatment of such curves, as the treatment depends upon the character of the asymmetry. It will be sufficient to say that during a period of acceleration in the increase of the measurement the average will always be too great as compared to the typical value for the period under consideration, while for a period of retardation in the increase of the measurement the reverse is the case. For this reason the values for average statures at a certain age which have been computed so often have no biological value as typical statures for the respective age.

I believe I have shown that we must exercise great care in the application of the method of averages, particularly that we cannot assume the average to be the type of a series without a careful scrutiny of its character.

This is still more true if we consider correlations of measurements. It is generally assumed that when a group of measurements of a series of individuals is taken the combination of the average of the measurements will represent the typical individual. Dr. Sargent's statues of the typical American are based on this assumption. The first objection to this assumption is based on the well-known fact that, if a variable is given and a function of the same, then the average of the function is not identical with the function of the average of the variable.

Furthermore, the general distribution of the measurement may apparently correspond to the law of chance, although a number of distinct types are represented in the series whose presence may be revealed by a classification of the whole series. For example: If the measurements of the Indians around the Great Lakes were tabulated without a subdivision into tribes, it would be found that their length of head and breadth of head are distributed according to the laws of

chance. The average length of head would be 193 mm., the average breadth of head 155 mm. According to the method under consideration, this would be the typical combination. When the tribes are properly subdivided in an eastern and a western group, it will be found that the length of head is 195 mm. in the west, 191 in the east, and that 193 does not represent the type of any one tribe. These people speak the same language, and might be gathered on one reservation. In that case a subdivision would be impossible, and an erroneous result would be obtained. Therefore, a critical study of distributions must precede the establishment of the type. The theory of statistics points to a clear way for this study, but unfortunately it has never been applied up to this time. The study must be based on a comparison of the variabilities of measurements. Whenever the variability of a measurement that is correlated to another one is abnormally increased we must suppose that there is an intermixture of types.

I must add a few words regarding the subject of correlations.

The admirable investigations of Mr. Alphonse Bertillon and those of Sören-Hansen, Bischoff, and others have proved that with increasing height all other measurements increase not proportionally, but at a slower rate. This law may be given a wider meaning by saying that whenever a group of people are arranged according to one measurement, with the increase of this measurement all others increase at a slower rate, the rate being the slower the slighter the correlation. This law leads us to establish the fact that we must consider each measurement as a function of a number of variable factors which represent the laws of heredity and environment. The correlation of two measurements will be close when they depend largely upon the same factor, slight when they depend largely upon distinct factors. This difference in the degree of correlation, which is a well-established fact, proves that the system which is applied in many of our

gymnasia is faulty. If the teacher of the gymnasium is given a pupil whose stature is, for instance, such that twenty per cent of all the individuals of his age are taller than he, then it is his ideal to train the pupil to that point that all his other measurements come up to the same standard. If all the men who have this particular stature were plotted alone, it would be seen at once that their measurements would be quite different from this assumed standard. This fundamental objection has already been raised by Dr. L. Gulick.

This assumption is one of the developments of the method of percentile grades. While this method has certain advantages in bringing home to the untrained public some of the valuable results to be gained from anthropometric inquiries, it is highly objectionable for theoretical studies. It does not explain any fact that cannot be explained just as well and with the tenth part of labor and with greater satisfaction by the method of mean variations, and whenever it has been applied it has proved to be misleading in so far as it suggests always that a certain percentile grade represents certain groups of individuals. For instance, during the period of growth, the average eighty per cent child has been assumed to represent, "on the average," the same child, which is most assuredly not the case. This method ought, therefore, to be applied with much greater care and for much more limited purposes than has been done heretofore.

I hope my remarks have served to point out some of the directions in which the theory of anthropometric statistics needs further treatment, and what defects remain to be remedied. I have in my full paper given a number of examples and elaborated the theories and methods which here I could indicate only with a few words.

ON THE APPLICATION TO INDIVIDUAL SCHOOL CHILDREN OF THE MEAN VALUES DERIVED FROM ANTHROPOLOGICAL MEASUREMENTS BY THE GENERALIZING METHOD.

By W. Townsend Porter, M.D.,

Assistant Professor of Physiology in the Harvard Medical School.

I.

The method employed by Quetelet in his anthropometrical studies of the phenomena of human growth was based on two fundamental propositions, (1) the mean of a great number of individuals of the same class is the typus or norm of the class; and (2) the deviations of individuals from the typus follow the law of accidental causes, and are subject to the calculus of probabilities.

From these propositions it results that the typus in any dimension, *e. g.*, height, at any age in the period of growth, is the mean of a sufficiently large number of observations of that dimension at the given age, and that the degree with which the observed approaches the true mean can be determined by an application of the principle of least squares.

When the means of any one dimension, for example, height at each age in the period of growth, are compared, the law of growth in that dimension is at once apparent, and may be expressed graphically in a curve whose abscissæ are years, and whose ordinates are centimetres, kilogrammes, or other units of measurement. Not only is the mean at any age thus fixed, but the probability of any given deviation from that mean is fixed as well. Thus the mean height of 2192 St. Louis Public School girls,* aged 8, is 118.36 cm., with a probable error of

* W. Townsend Porter, "The Physical Basis of Precocity and Dullness," *Transactions of the Academy of Science of St. Louis*, Vol. VI, No. 7, March 21, 1893, pp. 161-181. Also "Untersuchungen der Schulkinder in Bezug auf die physischen Grundlagen ihrer geistigen Entwickelung," read before the Berliner Gesellschaft für Anthropologie, Ethnologie, und Urgeschichte, July 15, 1893, and published in Virchow's *Zeitschrift für Ethnologie.*

0.079 cm., and a probable deviation of 3.7 cm. This being known, it follows that of the 50 per cent of those who exceed the mean

25	per cent	should	fall	between	118.36 cm.	and	122.06 cm.
16.2	"	"	"	"	122.06 "	"	125.76 "
6.7	" .	"	"	"	125.76 "	"	129.46 "
1.8	"	"	"	"	129.46 "	"	133.26 "

and 0.3 should exceed 133.26 cm., while the remaining 50 per cent should deviate from the mean in a precisely similar manner, but in an opposite direction.

The method admits of still another application. It is evident that in the series just given 122.06 cm. is the height of a girl who is taller than 75 per cent of the girls of her age, and not so tall as the remaining 25 per cent. Her position is thus definitely fixed with relation to the mean. She is in fact the typus or mean of the 50 per cent who exceed the mean of the whole number. The height of such an individual at any age would equal $M+d$, where M is the mean height of the age, and d the probable deviation. The values of $M+d$ determined for each age in the period of growth are comparable, and reveal the growth of the typus of the 50 per cent who exceed the mean of the whole number at each age. The growth of the typus of the 50 per cent who fall below the mean height can be similarly made plain, and, by continuing the process, the law of growth at any given deviation from the mean can be determined.

The data for these studies can be collected either by the "generalizing" or "individualizing" plan. In the former, a great number of measurements is made but once on individuals of different ages, and the measurements classified according to age. In the latter, the same individuals are measured yearly, or oftener, during their period of growth, and the measurements classified also by age. The generalizing method is rapidly and easily carried out, whereas the individualizing method demands for its execution exceptional opportunities and exceptional patience, requiring not only

that the measurements be made and the records kept through two decades, but that the number of children measured in the early years of this long period be very great, lest death and desertion so thin their ranks that those remaining to the end shall be too few to yield reliable conclusions. Both methods, when applied to the same material, give identical results with regard to means, including those of subdivisions as well as those of the whole number of observations at any age. The individualizing method does more.

The importance of the individualizing method has been much emphasized, for the reason that it can give information without which the laws derived from means cannot, in the present state of knowledge, be applied to individuals. Before this application can be made it is necessary to know the degree of probability that an individual who at a given age stands at a certain deviation from the mean of any dimension will show the same deviation at other ages; for example, the degree of probability that a girl whose height at age 8 is 122.06 cm., and who therefore deviates 3.7 cm., or $+d$ from the mean (118.36 cm.) of her age, will deviate to the same degree ($+d$) from the mean height throughout her growth. In that case the law of growth for the typus at a deviation of $+d$ from the mean is her law of growth. Otherwise she is an exception, and practical regulations deduced from the law for the typus cannot be safely made binding on her. This knowledge, as has just been said, is furnished by the individualizing method, while the generalizing method is of no assistance in this matter.

The application to individuals of the law of growth of the mean is a subject of immediate practical interest. The connection between theory and practical affairs is here unusually short and clear. Were this application possible, the deviations of children from the laws of normal growth could be quickly recognized, and by timely treatment largely overcome, the evil effects of over-study could be watched and intelligently combated, and systems of education, no longer

exacting from all that which should be exacted only from the mean, could be rationally adapted to the special needs of the exceptionally weak and the exceptionally strong. These beneficent reforms, it is at present believed, must await the slow collection of data by the individualizing method. If it is indeed true that the laws of growth determined for the mean cannot be used for the individual until the individualizing method has established the probability of each individual deviation remaining constant throughout the period of growth, then a generation must elapse — so slow is the gathering of data by this method — before the necessary knowledge is in our hands. I hope to show that this long waiting is unnecessary, and that the data collected by the generalizing method may be used, in a way hitherto unrecognized, for the making of standards by which the deviation of an individual from the mean of his age can be seen to be normal or abnormal.

Let the problem be clearly understood. The question is: This boy or girl is above or below the mean height, or weight, etc. of his or her age,— how shall it be known that this deviation is normal or abnormal? There has been hitherto no satisfactory reply to this question. A vague and partial answer is possible after two measurements separated by at least a year's interval. If the deviation is the same, or very nearly the same, at both measurements, the probability is that the child is growing normally. This probability is greater than the general probability that a normal deviation is more likely to occur than an abnormal one, but its numerical value is wholly unknown. If, on the other hand, the two deviations are unequal, the probability is that the greater of them is abnormal, but the numerical value is here also unknown. How definitely the individualizing method could answer this question is difficult of conjecture, in the present lack of data, but certainly no answer whatever could be expected until after two measurements separated by a year's interval,— a year in which the unchecked cause of an abnormal deviation

might inflict irreparable damage on the organism. Such indefinite and fragmentary knowledge can never be the basis of a practical reform. Any solution of this problem which shall gain general acceptance must be easy to understand and easy to apply, and must give the probable degree of abnormality of any observed deviation. These conditions are, I believe, fulfilled by the following method.

According to the theory of probabilities the heights of a thousand individuals of the same class will arrange themselves as follows: —

[Where M = the mean, and d = the probable deviation]

	$+n\,d$	3
	$+4\,d$	18
	$+3\,d$	67
	$+2\,d$	162
	$+\ d$	250
M		
	$-\ d$	250
	$-2\,d$	162
	$-3\,d$	67
	$-4\,d$	18
	$-n\,d$	3

Let these be divided into seven groups: —

I.	All	individuals	between	$+n\,d$	and	$3\,d$	21
II.	"	"	"	$+3\,d$	"	$2\,d$	67
III.	"	"	"	$+2\,d$	"	$+\ d$	162
IV.	"	"	"	M	"	$+\ d$	500
V.	"	"	"	$-\ d$	"	$-2\,d$	162
VI.	"	"	"	$-2\,d$	"	$-3\,d$	67
VII.	"	"	"	$-3\,d$	"	$-n\,d$	21

The mean height, weight, girth of chest, etc. of each of these groups at any given age will be the typus of a certain degree of deviation from the mean of the age,—that is to say, the heights, weights, etc. of each group will be symmetrically distributed above and below the mean height, weight, etc. of the group in the manner already illustrated for the entire undivided number of observations, *i. e.*, the entire

thousand. Each group, therefore, will be characterized by a physical development definitely determined by the means of height, weight, and other physical dimensions. These means taken together form the typus or norm of the group. The individual deviations from this norm follow the theory of probability, and the degree of abnormality presented by any individual deviation can be expressed in the terms of this theory. An example will illustrate this: A boy x shows a deviation in height of $+1, 5\ d$ from the mean height of his age; he falls therefore in group III. The boys in this group possess a mean weight of M^1 kilog., with a probable deviation of $+d^1$, that is, boys from d to $2\ d$ taller than the norm of their age should weigh $M^1 + d^1$ kilog. In like manner they should possess a girth of chest of $M^2 + d^2$ centimetres, and a span of arms of $M^3 + d^3$ cm., and so on. If the weight, etc. of the boy x coincide with the means of his group (group III) his physique is normal, the accuracy of this conclusion being proportionate to the number of different measurements on which it is based. If the boy x deviate more than $\pm d$ from the mean in one or more dimensions his development is abnormal, and the degree of abnormality is measured by the amount of his deviation.

The necessity of choosing some one dimension as a basis of such a system of measurement is self-evident. There are good reasons, partly theoretical and partly practical, why height rather than weight should be taken as a basis. Height is more stable, less liable to irrelevant fluctuations than weight. An excess in weight can be reduced; a child whose weight is out of proportion to its height may be brought into proportion by suitable diet and exercise; but height once attained cannot be reduced, nor can the growth in height be easily influenced. Practically, therefore, the physical trainer must be content to bring the weight, girth of chest, strength of squeeze, and other physical dimensions up to the mean development which corresponds to the height of the child. Experience has abundantly shown that the relation of weight

to height is of great importance to health, life insurance companies declining to receive applicants whose weight falls much below the standard weight of their height. For these reasons height should be preferred as the basis of the system.

The question whether any given deviation is normal or abnormal is answered by this system in two ways: in respect of height, by the degree of deviation from the mean or norm of the whole number of observations; in respect of other dimensions, by the degree of deviation of the weight, girth of chest, etc. from the mean weight or girth of chest corresponding to the height of the individual under examination, this normal weight, etc. being determined with sufficient exactness by taking the means and probable deviations of the group in which the height falls. It is evident that all cases included within $M \pm d$ must be termed normal, for the chances are even that any individual measurement in a series will fall within $M \pm d$, and are against its exceeding these limits, being 4.64 against 1 that it will fall at $M \pm 2\,d$.

Strictly speaking, all abnormal deviations in any dimension are probably unhealthful, yet an important difference exists in this respect between abnormal deviations in height and abnormal deviations in weight, girth of chest, etc. as related to height. It cannot be doubted that abnormal height is probably (using the word in its technical sense) a disadvantage. The potential energy of the body is converted into mechanical labor and heat, by far the greater expenditure taking the latter form. In the adult the total expenditure in the form of heat is about 2700 calories in 24 hours (Helmholtz), of which 80.1 per cent escape in radiation, conduction, and evaporation from the skin. Thus the superficies of the body plays a great part in the dissipation of energy. The superficies is greater usually in tall children than in short, a difference of special importance in the young, in whom metabolism is much more active than in the adult. More heat is therefore lost by the abnormally tall than by those of normal height. There is a disadvantage also in the loss by mechan-

ical labor. Greater height entails increased work on the heart and on the skeletal muscles. In short, increased loss of energy goes hand in hand with increase in height. Hence in the tall the necessity of a physical development which shall be so much above the mean as to compensate their greater loss of energy. In growing children not only must there be compensation for the expenditure of energy, but there must be energy stored in the increase of tissue which constitutes growth.

If the greater demands of tall children are balanced by a correspondingly greater income of energy, a normal equilibrium or "health" is preserved. It should be clearly recognized that this equilibrium is unaffected by the absolute height, and is dependent only on the relation between height and the other physical dimensions. Consequently, health is as possible in tall children as in those of normal height, although less probable, for the chances against a compensatory development of weight and other dimensions increase very rapidly with the deviation of the height from the norm. The absolute height of an individual is, therefore, of very secondary interest from a practical point of view, because it is not necessarily a state of ill health, whereas the development of weight, girth of chest, etc. in proportion to height is of supreme interest. The lack of proportion between height and other physical dimensions is itself ill health. The tendency of organisms to adapt ends to means is strong, and an imperfect compensation may suffice for most demands. A heart in which an hypertrophy of the left ventricle has partially compensated an insufficiency of the mitral valve may beat regularly enough for ordinary exertions, and yet fail utterly when its possessor is forced to suddenly ascend a height, or to make any other unusual exertion. So a tall child may have a sufficient income of energy to meet the demands of a wisely regulated life, and sink under the burden of unusual tasks.

It has been shown in the foregoing pages that the means derived from anthropometrical measurements by the generalizing method can be used to determine whether the weight and other physical dimensions of an individual are normal in relation to height, and it has been pointed out that this normal relation constitutes the health of the individual. It follows that the normal amount of labor cannot be exacted without injury from those in whom this normal equilibrium is wanting. These facts must therefore be taken into account in a rational school system, and it should now be made plain how this is to be done.

II.

All systems of education have for their object the largest possible development of individual minds. In large schools the tasks by which this development is promoted are those which secure from the child of mean ability its maximum mental output. In practice they are determined by examinations. Hence the existence in every educational institution of classes or grades based on the mental output of the mean pupil, and related to age only in that the output fixed as the standard of any class is necessarily found more often at a certain age than at other ages. Thus there exists a mean age for each class, the greater number of pupils at any age being found in the same class, while some have advanced beyond, and others, equally old, have not yet come so far as this class.

On an average, those who have advanced beyond the greater number of their age are precocious, that is, possess more than the mean capacity for mental labor, while those who are less advanced are dull, possessing less than the mean capacity. It has been demonstrated that there is a physical basis for precocity and dullness.* When numbers sufficiently large for safe statistical work are employed, it is seen that precocious pupils possess a greater mean weight, height, etc. than the mean pupils, and that the latter are heavier and

* W. Townsend Porter, *loc. cit.*

taller than the dull. The mental output is therefore directly related to the physical condition of the pupils. The mean height, weight, girth of chest, etc. in any grade is the mean physical development corresponding to the mental output of the grade. It follows that those who do not possess this development cannot, without abnormal strain, do the work exacted in this grade. On the other hand, pupils who possess more than the mean physical development of their age should be capable of more than the mean labor. Yet the management of this latter class presents but few difficulties, whereas the former class cannot be too carefully protected.

The consequences of continued overstrain in a growing boy or girl are most unhappy. The curves of growth in height and weight of the mean child are characteristic. The quick rise to age 7 or 8, the slower ascent to age 11 in girls and 13 in boys, the remarkable three years of accelerated development preceding puberty, and, finally, the rapid decrease in the rate of growth as full development approaches express the normal development of the type, and, presumably, the normal development of the individual. Overwork may cause a temporary or a permanent deviation in these curves. It is probable, though not certain, that a temporary loss, consequent on a slight overstrain, may not lower the final outcome of the development, but there can be no doubt as to the result of a prolonged strain. In such a case, the probability is strong that the whole subsequent curve will be turned out of its course. A prolonged strain in a growing child harms for life, and leaves a mark which can never be effaced. The danger is greatest in the periods of quickest development, particularly great in the prepubertal period. It is a sufficient commentary on the evils of the present educational methods that during these very years the indiscriminating routine of a system devised for the average pupil is most inflexibly applied to weak and strong alike.

Overstrain can often be recognized both by subjective and objective symptoms. Subjective symptoms, however, are

frequently obtained with difficulty, especially in pupils who are unusually ambitious, and who over-study from choice. An objective symptom is therefore necessary,—a symptom easily demonstrated and almost never wanting. Such a symptom is the failure to gain weight at the normal rate. A persistent loss of weight in an adult is regarded as a matter of grave concern; the persistent failure of a child to make the normal gain in weight is no less grave. It is not pretended that the failure to gain weight always accompanies overstrain, but it is claimed that the number of exceptions is small, and that frequent weighing is the most practical and, in the whole, the most certain method of detecting the presence of influences that are working injury to the development of the child. The skillful breeder of cattle depends on systematic weighing to inform him whether his efforts to secure well-developed animals are meeting with success, but children are left to grow at hap-hazard.

It is not enough that overstrain should be recognized by the harm it has done. The child should be guarded against the possibility of harm. The anthropometrical system proposed in this article offers a means of doing this. It infallibly discovers those whose physical development is below the standard of their age. It no less certainly indicates the physical development which most often accompanies the power to do the mental work of any grade. It therefore divides the pupils into two bodies, those physically competent and those physically incompetent for a clearly defined degree of mental exertion. When working with great numbers, the infallibility of this system is practically absolute and theoretically almost absolute. When applied to individuals, errors will certainly occur, but the number of errors will, according to the laws of probability, be less than the number of correct conclusions. And these errors cannot influence the great fact that such a system is competent to call attention to the children who shall probably be unable to do the normal work of their age without injury. Each individual case must then be treated on its own merits.

The proposed system of physical examination requires—

I. The collection of sufficiently extensive data by the generalizing method.

II. The determination of the means and the probable deviations of height, weight, girth of chest, strength of squeeze, etc. for each age.

III. The division of the individuals at each age into groups in terms of the probable deviation from the mean height, as illustrated above, and the calculation of the mean and probable deviation of the weight, girth of chest, etc. of each group.

IV. The determination of the mean physical development of the pupils in each class or grade of the school system.

V. The physical examination of each applicant for entrance to any grade.

These data permit the enforcement of the following regulation: No pupil whose physical development deviates more than $\pm d$ from the weight, etc. of the mean pupil of his height in a class which his mental output would otherwise entitle him to enter shall be admitted to that class unless with the approval of a medical expert, if possible a regularly appointed school physician, who shall testify that the pupil's strength shall be equal to the strain.

ANTHROPOMETRIC STATISTICS OF AMHERST COLLEGE.

By Edward Hitchcock, M.D.

When the Department of Hygiene and Physical Education was established in Amherst College, about thirty years ago, one of the very first things accomplished was the securing of bodily measurements and tests of every student as he entered the college, and again at intervals. This has been kept up with increasing accuracy and enlargement, and is still an important feature of the department. It has been the habit of the department to furnish at many of the public occasions of the college, along with the schedule of the exercises, some anthropometric and other closely connected statistical details in a printed form.

The first work to be mentioned is the result of five years' record of the measures of all the students of college, in eight items of inquiry, from 1861 to 1865. These averages were:

Age, 21 years and 4 months.	
Weight, without clothes, . . .	137.9 pounds.
Height, ...	67.8 inches.
Chest girth, without clothes, . .	35.3 "
Arm girth, ...	11.3 "
Forearm girth, ...	10.9 "
Capacity of Lungs, ...	237.2 cubic inches.
Measure of strength, ...	11.3

During the same five years the *sickness of college students* as averaged to each man, and to the four classes, was recorded. In this study each man in college lost 2.34 days of the year from sickness or accident, a man being regarded as "sick" who was absent three or more consecutive days from all college exercises.

The number of individuals who were sick during this period, giving the average of each class, was found to be: —

Seniors, ...	5.6 men.
Juniors, ...	7.0 "
Sophomores, ...	10.8 "
Freshmen, ...	12.8 "

showing that health increased during the college course.

Some items were gathered in a study of ten years, by classes, with reference to sickness, as before mentioned, and the results were as follows: —

Seniors,	averaging	50.0	men,	had	6.6	on	the	sick	list.
Juniors,	"	53.2	"	"	9.1	"	"	"	"
Sophomores,	"	62.9	"	"	12.6	"	"	"	"
Freshmen,	"	64.1	"	"	14.9	"	"	"	"

And in this same period the average loss of time to each sick man was 11.4 days, and to all the college of 2.1 days. There also were among these men 43 different maladies, of which 33 per cent were colds and 9 per cent physical accidents and injuries.

Still later, statistics of 14 years' duration for 3488 students were compiled, and the following law seemed to be deducible: The rate of difference in numbers between freshmen and sophomores was 6 per cent, and the decrease in sickness 15 per cent. Between the sophomore and junior classes the numerical difference was 14 per cent, and the decrease in sickness 17 per cent. The falling off in numbers from junior to senior years was 8 per cent, and the sickness decreased to the amount of 30 per cent.

A study of the viability of the first 39 classes of the college —1821 to 1860 — on the living condition of these graduates has also been a matter of study. The average viability was 84 per cent, or 16 per cent mortality in classes, averaging at their graduation 24 years of age.

Another study during 1874 was (see *Table A*, p. 590) —

Table A.

Some of the Anatomical and Physiological "Constants" of a student of Amherst College. Determined by 4311 observations recorded during the past thirteen years, with the relative percentage of the different classes, the Freshman as the unit of comparison.

	Age in Years.	Relative per Cent.	Weight in Pounds.	Relative per Cent.	Height in Feet.	Relative per Cent.	Chest Girth in Inches.	Relative per Cent.	Arm Measure in Inches.	Relative per Cent.	Forearm Measure in Inches.	Relative per Cent.	Utmost Lung Capacity in Cubic Inches.	Relative per Cent.	Test of Strength.	Relative per Cent.	Relative Class Percentage.
Seniors.....	22.403	1.164	142.239	1.067	5.681	1.016	35.755	1.014	11.716	1.033	11.141	1.020	259.610	1.093	11.427	1.201	1.076
Juniors.....	21.941	1.140	141.552	1.062	5.682	1.016	36.006	1.022	11.676	1.029	11.060	1.013	254.341	1.071	11.411	1.200	1.069
Sophomores....	20.700	1.075	138.395	1.038	5.663	1.013	36.107	1.025	11.638	1.025	11.062	1.013	256.222	1.099	10.700	1.125	1.051
Freshmen.....	19.248	1.000	133.331	1.000	5.590	1.000	35.236	1.000	11.351	1.000	10.920	1.000	237.445	1.000	9.512	1.000	1.000
All.....	21.073	1.095	138.879	1.042	5.654	1.011	35.776	1.015	11.595	1.021	11.045	1.011	251.904	1.061	10.512	1.105	1.049

In 1879 the average and mean measurements of 1262 students, attending between 1861 and 1878, were contrasted in respect to six items. The contrasts are here shown. The average age was 21 years and three months.

	Mean.	Average.
Weight in pounds,	127	139
Height in inches,	67	66
Chest girth in inches,	36	36
Arm " " "	11	12
Lung capacity in cubic inches,	220	250
Pull up, number of times,	12	11

26,060 measures of 1321 students of the six items below gave strength to the belief that the body gains its physical perfection between 26 and 30 years of age.

It is generally accepted as a law that bodily growth continues until the age of 30. This law, however, is not verified by these statistics when studied by the single years of observation, owing probably to an insufficient number of data, and specially above the age of 24. But on grouping the years thus: All under 20; all from 20 to 24, inclusive; and all from 25 to 29, inclusive, there is a very close illustration of the general law, as is seen by this table.

Age.	Weight.	Height.	Chest Girth.	Arm Girth.	Lung Capacity.	Body Lift.
Under 20	133.50	66.20	34.75	11.33	233.85	9.88
20 to 24	140.28	68.12	36.25	11.78	254.23	10.68
25 to 29	143.40	68.48	36.85	11.69	264.66	10.64

See *Table B* on page 39.

After 20 years of gathering and recording anthropometric statistics of our students several tables were compiled relating to physical measures, growth and development, the sick list, and the maladies. These are here inserted.

See *Table C* on page 40.

Table B.

The average results of the measures of the weight, height, chest, arm, lung capacity, and body lift of 1321 different students of Amherst College during the years 1861–62 to 1877–78, inclusive.

Age in Years.	Number.	Weight in Pounds.	Number.	Height in Inches.	Number.	Chest in Inches.	Number.	Arm in Inches.	Number.	Lung Capacity in Cubic Inches.	Number.	Times Lifted.	Total Numbers.
17	42	131.821	42	66.156	42	33.847	42	11.131	42	220.27	40	8.47	250
18	573	133.250	573	66.596	573	35.019	573	11.353	551	237.31	571	10.35	3,414
19	751	135.440	751	67.068	751	35.397	751	11.514	715	243.96	751	10.83	4,470
20	759	138.106	759	67.800	759	35.723	759	11.584	726	249.52	757	10.54	4,519
21	722	139.529	722	67.716	722	35.748	722	11.828	697	249.93	721	10.73	4,306
22	523	140.852	523	68.148	523	36.109	523	11.819	496	253.65	520	10.98	3,108
23	382	140.680	382	68.260	382	36.330	382	11.901	360	256.83	380	10.73	2,268
24	258	142.249	258	68.676	258	37.365	258	11.794	247	261.22	256	10.44	1,535
25	144	145.029	144	68.832	144	36.025	144	11.777	140	264.15	143	10.01	859
26	106	144.261	106	68.436	106	38.528	106	11.780	96	262.63	104	10.50	624
27	57	143.911	57	68.316	57	36.923	57	11.851	54	266.20	56	10.53	338
28	27	141.129	27	68.664	27	36.374	27	11.574	24	269.79	26	12.31	158
29	19	142.684	19	68.076	19	36.415	19	11.513	19	260.52	15	9.86	110
30	18	146.500	18	69.192	18	36.705	18	11.611	17	279.65	12	7.50	101
	4,381		4,381		4,381		4,381		4,184		4,252		26,060

Table C.— Measures of 2106 different students of Amherst College, showing the Averages of each class for twenty years, in Age, Weight, Height, Chest Girth, Arm Girth, Forearm Girth, Lung Capacity, Body Lift, Finger Reach, Chest Expansion, and the Comparative Right and Left Hand Strength.

	Number Observed.	Age.	Weight.	Height.	Chest Girth.	Arm Girth.	Forearm Girth.	Lung Capacity.	Body Lift.	Finger Reach.	Chest Expansion.	Right Hand Strength.	Left Hand Strength.	Per Cent Strongest with Right Hand.
Seniors.....	1,113	22.24	142.19	67.94	35.97	11.77	11.21	251.05	11.33	69.72	3.18	92.02	86.48	93
Juniors.....	1,148	21.87	140.59	67.86	35.61	11.72	11.07	250.07	11.31	69.78	3.33	88.99	85.98	97
Sophomores....	1,263	20.57	139.39	67.53	35.44	11.69	11.06	249.23	10.58	69.70	3.45	90.45	86.05	96
Freshmen.....	1,489	19.31	133.19	67.33	34.76	11.23	10.80	233.08	8.61	69.60	3.00	87.83	83.34	96
College Average	5,013	21.10	138.84	67.66	35.40	11.19	11.02	241.79	10.25	69.69	3.02	89.69	85.50	95
College Mean..	.....	.....	131.00	67.50	35.50	11.25	. ...	230.00	11.00	.....	....	.....	.....	....

Table D.— Showing the Maxima and Minima of every measurement of the 2106 students observed.

	Age, Years and Months.	Weight in Pounds.	Height in Inches.	Chest Girth in Inches.	Arm Girth in Inches.	Forearm Girth in Inches.	Lung Capacity in Cubic In.	Body Lift.	Finger Reach in Inches.	Chest Range in Inches.
Maxima.....	35.6	216	76.5	43.00	15.5	15.00	426	65	81.10	5.50
Minima.. ..	15.3	84	58.0	27.25	8.0	8.25	115	2	48.00	1.50

Table E.— The *Mean Observations* of the measures of Amherst College students for twenty years, from a total of 34,384.

Weight in Pounds.	Number.	Height in Inches.	Number.	Chest Girth in Inches.	Number.	Arm Girth in Inches.	Number.	Lung Capacity in Cubic Inches.	Number.	No. of Times Body Lifted.	Number.
175	69	72	104	40	61	14.0	44	340	53	21	88
167	105	71	291	39	165	13.5	81	320	94	20	176
159	238	70	385	38	394	13.0	323	300	275	18	372
151	490	69	808	37	704	12.5	602	280	608	16	610
143	798	68	955	36	1,079	12.0	1,117	260	871	14	790
135	1,157	67	986	35	1,164	11.5	1,205	240	1,287	12	940
127	1,198	66	790	34	1,098	11.0	1,245	220	1,275	10	1,075
119	982	65	571	33	682	10.5	658	200	732	8	796
111	487	64	371	32	310	10.0	316	180	379	6	590
103	163	63	208	31	104	9.5	77	160	148	4	302
95	46	62	65	30	41	9.0	17	140	39	2	120
	5,733		5,534		5,812		5,685		5,761		5,859

Table F.— Data of Student Sickness and Physical Disability for nineteen years and nine months in Amherst College.

Students' names on the annual Catalogues, 1861 to 1881, inclusive, 5443.

	Names on An'l Catalogues for 20 Years.	Names on Sick List.	Per Cent of Each Class to Whole College.	Per Cent of Sickness in Each Class to Whole College.
Seniors.....	1,192	260	21.90	19.05
Juniors.....	1,270	319	23.33	23.37
Sophomores.....	1,465	386	26.92	28.28
Freshmen.....	1,516	400	27.85	29.30
	5,443	1,365	100.00	100.00

Students on the sick list, ... 1,375
Cases (not individuals) of sickness, ... 1,725
Cases on sick list more than once in the year, . 350
Per cent of college on the sick list, ... 25.26

Table G.— The Maladies of the students, and their proportion, when it equals one or more per cent of the whole. This is the number of *cases*, not students.

Maladies.	Per Cent.	Maladies.	Per Cent.
Colds, Pneumonia, Bronchitis, etc.	37.4	Liver and bilious.....	2.3
Physical injury.....	8.8	Neuralgia.....	1.8
Febriculœ.....	4.8	Malaria.....	1.7
Eyes, weak and sore.....	4.7	Mumps.....	1.7
Quinsy and sore throat.....	4.6	Diphtheritic.....	1.1
Boils.....	4.1	Measles.....	1.1
General inability.....	3.1	Teeth.....	1.1
Typhoid fever.....	3.1	Stomach.....	1.1
Bowels.....	2.6	Overwork.....	1.0

Table H.— The measures of Weight, Height, Chest, Arm Girth, Lung Capacity, and Body Lift of 2106 different students of Amherst College, arranged by age.

Age.	Number of Observations.	Weight.	Height.	Chest.	Arm.	Lung Capacity.	Body Lift.
17	330	131.99	66.60	33.87	11 12	224.8	8.58
18	1,172	134.07	66.96	35.10	11.36	238.7	10.35
19	1,511	135.84	67.30	35.38	11.52	240.3	10.82
20	1,358	138.12	67.95	35.52	11.57	248.8	10.97
21	1,171	140.00	68.01	35.58	11.69	250.1	10.84
22	807	141.07	68.11	35.98	11.77	250.8	10.92
23	559	141.21	68.31	36.29	11.71	257.0	10.63
24	362	142.42	68.44	37.23	11.74	261.0	10.62
25	216	145.12	68.68	36.66	11.79	263.6	10.11
26	141	144.91	68.82	37.46	11.81	262.5	10.71
27	71	144.40	68.30	36.95	11.84	268.4	10.37
28	30	140.71	68.52	36.28	11.57	269.8	8.51
29	19	142.68	68.09	36.41	11.51	260.5	9.86
30	18	146.50	69.19	36.70	11.61	279.5	7.50

Table I.— **Giving the measures of 749 students of Amherst College at two intervals of three years and six months, and at an average age of 19 years and two months at the first observation, showing their physical development during this period.**

		Per Cent.
Number of *men* measured, ...	749	
" " increased in all items, ...	196	26.15
" " decreased in some items, . . .	401	53.40
" " both same and increased items,	355	47.39
" " both same and decreased items,	211	28.17
Number of *items* secured, ...	5,160	
" " showing increase, ...	3,972	76.97
" " same Freshman and Senior year,	487	9.43
" " less in Senior year, ...	701	13.58

	Weight. Pounds.	Height. Inches.	Chest. Inches.	Arm. Inches.	Forearm. Inches.	Lung Capacity. Cubic in.	Body Lift.
Greatest individual gain...	56.00	6.00	6.50	4.000	3.500	1.34	25.00
Averages of increased men	12.27	1.05	1.45	0.853	0.685	28.40	4.50
Per cent of decreased items	11.00	....	20.31	13.460	25.270	14.64	20.13

Some statistics have been gathered showing the differences between the "average" and the "mean."

Sir John Herschel has said "an average may exist of the most different subjects, as the height of houses in a town, or the size of books in a library. It may be convenient to convey a general notion of things, but it involves no conception of a natural and recognizable central magnitude, all differences from which ought to be regarded as deviations from a standard. The notion of a mean, on the other hand, does imply such a conception standing distinguished from an average by this feature, namely, the regular march of the groups, increasing to a maximum, and then again diminishing. An average gives us no assurance that the future will be like the past; a mean may be reckoned on with the most implicit confidence."

Table J.— Showing the average and mean measurements, in respect to six items, of 2106 students between 15 years and 3 months and 35 years and 6 months of age, with an average age of 21 years and 1 month.

Weight, . .	138.84 lbs.	=	63.00 k.	131.00 lbs.	=	59.40 k.
Height, . .	67.56 lbs.	=	1.72 m.	67.34 in.	=	1.71 m.
Chest girth, .	35.40 in.	=	89.90 c.m.	35.50 in.	=	90.00 m.
Arm girth, .	11.02 in.	=	27.99 c.m.	11.25 in.	=	28.57 c.m.
Lung capacity,	241.70 cu. in.	=	3960.70 c.c.	230 cu. in.	=	3769.40 c.c.
Body lift, . .	10.25 times.			11 times.		

A study was made showing the relation of the trunk, the arm reach, and the horizontal length of the body.

The results given below (*Table K*) were secured from measurements of 327 students, the whole college numbering 340. The measurements were taken during March and April, 1882, and the average age of all men measured was 21 years and six months.

One of the objects to be gained from this work is to learn the relation between the length of the cerebro-spinal column, the perpendicular height of the body, its length when extended horizontally, and the distance between the tips of the middle fingers when the arms are fully extended.

Medical Director Ruschenberger of the U. S. Army says: "It seems probable that the length of the cerebro-spinal column may be a more valuable element in estimating the physical qualifications of a recruit than total stature. Observation has led me to conjecture that as a rule men of average height, made up of a long trunk and comparatively short lower extremities, possess greater power to endure with impunity great labor and exposure to vicissitudes of all kinds than men who have comparatively long lower limbs and short trunk."

The relative measurements of these portions of body have been made, and the results are seen in the appended table. And these results are given by class averages, and by averages of the aggregate students, which are expressed both in the metric and in the English system.

The finger reach is	1.787 metres, or	70 355 inches.	
The horizontal length is . .	1.748 " "	68.820	"
The perpendicular height is .	1.729 " "	68.071	"
The sitting height is . . .	907 millimetres or	35.709	"

We seem, then, to learn from these statistics that a college student, as expressed by an Amherst average, may expect to give a trunk measurement proportioned to his total height of 1.1906. This is a difference of 822 millimetres, or about 32 inches, and the trunk is more than half the total height of the body. The difference in length between the body lying down and the body standing erect is 19 millimetres, or about three-quarters of an inch, in favor of the horizontal measure. The measure of the tips of the fingers exceeds the total height by 39 millimetres, or about one and one-half inches.

Table K.

	Number of Men.	Finger Reach.	Horizontal Length.	Height of Whole Body.	Sitting Height.
Seniors.....	64	1.805	1.776	1.773	910
Juniors.....	95	1.787	1.763	1.739	919
Sophomores.....	79	1.779	1.727	1.716	902
Freshmen.....	89	1.777	1.725	1.689	897
Average.....	.....	1.787	1.748	1.729	907

See *Table L* on page 45.

Up to nearly this time, 1882, our statistical work had been directed very much to averages, means, development, and growth. But all along the thought had been pressing itself forward that there is some standard by which to estimate the proper growth and development of the student; or at least we must have some method to work by advisedly. It was perhaps well enough for the average, the mean, the 50 per cent man, but what can we do for all the others? The thought of the *Stature or Bodily Height* seemed a desirable field to work in, and accordingly the whole effort was devoted to *arranging all the measurements in groups of heights running one centimetre each.* The first table of this descrip-

Table L.

Measures of the Weight, Height, Chest Girth, Arm Girth, Lung Capacity, and Pull Up of the students of Amherst College, gathered between the academic years of 1861-62 and 1884-85, inclusive, noted in the English and in the *Metric* system. Arranged and averaged by Age, and of 7988 individuals.

Age of the Students.	Number of Students Measured at Each Year.	Weight in Pounds and Decimals.	*Weight in Kilos and Tenths.*	Height in Inches and Hundredths.	*Height in Metres and Millimetres.*	Chest Girth in Inches and Hundredths.	*Chest Girth in Milli-metres.*	Arm Girth in Inches and Hundredths.	*Arm Girth in Milli-metres.*	Lung Capacity in Cubic Inches.	*Lung Capacity in Litres.*	Pull Up. Number of Times.
16	20	123.42	*56.1*	66.70	*1.695*	34.20	*868*	10.60	*268*	225.0	*3.68*	8.58
17	390	128.73	*58.5*	66.77	*1.697*	34.23	*870*	11.06	*280*	229.9	*3.80*	9.42
18	1,322	131.09	*59.6*	66.95	*1.700*	35.42	*895*	11.23	*285*	239.3	*3.97*	10.06
19	1,452	133.13	*60.5*	67.12	*1.709*	35.43	*896*	11.40	*290*	244.1	*4.02*	10.18
20	1,478	134.99	*61.3*	67.47	*1.714*	35.63	*905*	11.58	*295*	250.4	*4.11*	10.17
21	1,351	136.37	*61.9*	67.50	*1.716*	35.92	*918*	11.65	*298*	254.0	*4.18*	10.26
22	867	137.61	*62.5*	67.58	*1.720*	36.29	*926*	11.74	*300*	256.9	*4.20*	10.26
23	589	138.95	*63.1*	67.70	*1.721*	36.75	*934*	11.94	*303*	260.5	*4.28*	10.26
24	382	140.33	*63.8*	67.77	*1.722*	37.36	*940*	11.96	*304*	263.0	*4.30*	10.26
25	237	142.34	*64.7*	67.90	*1.726*	37.40	*947*	11.98	*305*	265.0	*4.36*	10.27

tion was made in 1884 from the height of 155 to 183 centimetres of 51 items of measurement from 628 men. Then each man as he was measured, with his record in his own hands, could see his exact relation to the average man of his own height, as determined by the records for many years past.

From this table were constructed cards — one for each centimetre — of the heights already mentioned, and containing the records of the 51 items observed, and side by side of his own record of measures. And upon this same card were given the directions and suggestions of the examiner, when there was a special lack of development, and one with the average of all college for work and development. Besides this it contained the directions for taking the measurements as adopted by the American Association for the Advancement of Physical Education, the method of examining the eyes and ears, and general directions for the use of the development apparatus in the gymnasium.

Two years later another edition of the manual was issued, and today, 1893, a third one is just from the press, with enlarged tables and data, but all tending to confirm the idea that stature is the foundation upon which the idea of the typical student should be constructed, and the source from which all corrections for imperfect or non-development should be made.

It is most interesting to note that the statue of the typical college student exhibited at the Chicago Exposition today most strongly exemplifies this idea.

To conclude, the results of Anthropometry in Amherst College as they stand today are to be found in the tables accompanying this paper, and in the revised tables contained in the third edition of the *Anthropometric Manual of Amherst College, 1893.*

AN ANTHROPOMETRICAL STUDY OF THE EFFECTS OF GYMNASTIC TRAINING ON AMERICAN WOMEN.

By Claës J. Enebuske, A.M., Ph.D.,
Principal of Instruction in the Boston Normal School of Gymnastics.

In order to trace the results of gymnastic training, the students of the Boston Normal School of Gymnastics are measured at regular intervals during the school year. The first measurements are taken at the beginning of the school work in the autumn; the last measurements are taken at the close of the school in the spring. At the beginning of each month those items which are most susceptible to change under the influence of the training are remeasured, and the change in which has most direct influence upon the working capacity and resistive power of the student, so far as is manifest in gymnasium work. The measures taken each month are the weight, lung capacity, strength of legs, back, chest, left and right forearm. At the beginning and close of the work 53 different measurements are taken in all, namely, the standing height, the length, breadth, depth, girth of various parts of the body, taken at distinct anatomical landmarks. Besides these a series of tracings of the form of the chest are taken at the beginning and close of the year. These are made by means of the anthropometric machines, constructed for this purpose by Démeny in Paris. They consist of, 1st, tracing of thorax in horizontal section, with chest in inspiratory — repose — and expiratory position; 2nd, tracing of the median profile of the trunk with chest in inspiratory, repose, and expiratory position; 3rd, the antero-posterior curve of the back; 4th, the mid-spinal line.

In the present paper we wish to present a part of the results attained by the study of the measurements of *one hundred junior students of the school.** The first observation

* The measurements have been made by Miss M. Anna Wood, of Wellesley College, and Miss Margaret S. Wallace, of the Boston Normal School of Gymnastics.

was made before the training began, or in the early part of the training; the second observation was made seven months later. During the intervening period, *i. e.*, from October to May, the students had one hour's gymnastic training five days a week, besides attending the required lectures and recitations. The ages of the students range from seventeen to forty-two years. The distribution of age at the beginning of the training is shown in the following table: —

TABLE I. AGE AT THE FOLLOWING PERCENTILE GRADES.

Percentile Grade.	5.	10.	20.	30.	40.	50.	60.	70.	80.	90.	95.
Years.....	19	19¼	20¼	21	22	23¼	25¼	27	30	35	37

Height. The highest and lowest statures of these 100 students were 171.3 and 147 centimetres, respectively. Table II shows the distribution of height before and after the training.

TABLE II. HEIGHT.

Percentile Grade.	5.	10.	20.	30.	40.	50.	60.	70.	80.	90.	95.	Unit.
Before the training.....	151.3	152.8	154.9	156.6	158.6	160.1	160.7	162.7	164.8	167.5	169.5	Centimetre.
After 7 months' training.....	152.0	153.0	155.0	156.8	158.8	160.2	161.5	163.2	166.5	167.6	169.6	

Weight. The highest and lowest weights observed in these cases are, before the training, 74.3 and 40.2 kilos., respectively; after the training, 72.9 and 38.4 kilos., respectively. Table III shows the value of the following percentile grades before and after training: —

TABLE III. WEIGHT.

Percentile Grade.	5.	10.	20.	30.	40.	50.	60.	70.	80.	90.	95.	Unit.
Before the training.....	43.5	45.0	47.5	49.5	51.5	53.4	55.0	57.5	59.7	63.1	65.8	Kilos.
After 7 months' training.....	43.5	44.8	47.1	49.1	51.7	53.3	55.2	57.3	59.4	62.1	66.4	

It will be seen that a slight diminution in weight has taken place generally (the exceptions being at the 40, 60, and 95 per cent grades).

Lung Capacity. The highest and lowest lung capacity observed in these cases are, before the training, 3.76 and 1.31 litres, respectively; after the training, 4.1 and 1.97 litres, respectively. Table IV shows the value of the following percentile grades: —

TABLE IV. LUNG CAPACITY.

Percentile Grade.	5.	10.	20.	30.	40.	50.	60.	70.	80.	90.	95.	Unit.
Before the training.....	2.13	2.27	2.40	2.46	2.56	2.65	2.75	2.87	2.95	3.07	3.35	Litre.
After 7 months' training.....	2.27	2.38	2.54	2.65	2.72	2.87	2.96	3.03	3.12	3.29	3.43	

It is seen that increase of lung capacity has taken place at all the percentile grades. After seven months' gymnastic training the value of the 30 per cent grade (2.65) is equal to the value at the 50 per cent grade before the training, and the value at the 50 per cent grade after the training (2.87) is equal to the 70 per cent grade before the training.

Strength of Legs. The extreme values observed are, before the training, 148 and 60 kilos., respectively; after the training, 190 and 81 kilos., respectively. Table V gives the value of the following percentile grades: —

TABLE V. STRENGTH OF LEGS.

Percentile Grade.	5.	10.	20.	30.	40.	50.	60.	70.	80.	90.	95.	Unit.
Before the training.....	68.0	70.0	78.0	80.0	88.0	93.0	100.0	105.0	119.5	131.5	139.5	Kilos.
After 7 months' training..... ..	87.5	94.5	100.0	108.5	115.0	120.0	127.5	135.0	145.0	160.0	168.5	

Increase has taken place at all the percentile grades. After the training the value at the 10 per cent grade (94.5) is higher than the value of the 50 per cent grade before the

training (93), and the 50 per cent value after the training (120) is higher than the 80 per cent value before the training (119.5).

Strength of Back. The extreme values were, before the training, 100 and 40 kilos., respectively; after the training, 124 and 48 kilos., respectively. Table VI shows the value of the following percentile grades: —

TABLE VI. STRENGTH OF BACK.

Percentile Grade.	5.	10.	20.	30.	40.	50.	60.	70.	80.	90.	95.	Unit.
Before the training	45.5	49.0	52.5	57.5	60.5	65.5	70.0	75.0	80.5	90.0	91.5	Kilos.
After 7 months' training	60.0	66.0	72.0	77.0	78.0	81.5	86.0	91.5	95.0	100.0	104.0	

Increase has taken place in all the grades. The 10 per cent value after the training (66) is higher than the 50 per cent value before the training (65.5), while the 50 per cent value after the training (81.5) is higher than the 80 per cent value before the training (80.5), and the 70 per cent value after the training (91.5) is equal to the 95 per cent value before the training.

Strength of Chest. The extreme values before the training were 37 and 15 kilos., respectively; after the training, 48 and 18 kilos., respectively. Table VII shows the value of the following percentile grades: —

TABLE VII. STRENGTH OF CHEST.

Percentile Grade.	5.	10.	20.	30.	40.	50.	60.	70.	80.	90.	95.	Unit.
Before the training	19.0	20.5	24.0	25.0	26.0	27.0	28.0	29.0	30.3	32.8	34.0	Kilos.
After 7 months' training	24.5	26.8	28.5	29.8	31.0	32.0	33.0	35.0	36.5	39.0	39.0	

Increase has taken place in all the grades. The 10 per cent value after the training (26.8) is slightly below the 50 per cent value before the training (27), while the 50 per cent

value after the training (32) is higher than the 80 per cent value before the training (30.3), and nearer the 90 per cent value (32.8) before the training.

Strength of Right Forearm. The extreme values were, before the training, 36 and 10 kilos., respectively; after the training, 39 and 19, respectively. Table VIII gives the value of the following percentile grades: —

TABLE VIII. STRENGTH OF RIGHT FOREARM.

Percentile Grade.	5.	10.	20.	30.	40.	50.	60.	70.	80.	90.	95.	Unit.
Before the training.....	16.0	20.0	22.0	24.0	25.0	26.0	27.0	28.0	30.0	31.5	33.0	Kilos.
After 7 months' training.....	20.0	23.0	24.5	25.0	27.0	28.0	29.0	30.0	32.5	34.5	37.0	

There is increase consequently at all the grades. The 50 per cent value before the training (26) is reached between the 30 and 40 percentile grades after the training, and the 50 per cent value after the training is equal to the 70 per cent value before the training.

Strength of Left Forearm. The extreme values were, before the training, 37 and 9 kilos., respectively; after the training, 38 and 16, respectively. Table IX gives the value of the following percentile grades: —

TABLE IX. STRENGTH OF LEFT FOREARM.

Percentile Grade.	5.	10.	20.	30.	40.	50.	60.	70.	80.	90.	95.	Unit.
Before the training.....	14.5	16.0	19.0	20.0	21.0	23.0	24.0	25.0	26.0	28.5	30.5	Kilos.
After 7 months' training.....	18.0	19.0	20.5	23.0	24.0	25.0	26.0	27.0	29.0	31.0	33.0	

Increase is found in all grades. The 30 per cent value after the training (23) equals the 50 per cent value before the training, and the 50 per cent value after the training (25) equals the 70 per cent value before the training.

Total Strength. By this term is understood the sum of the five strength tests mentioned. The extreme values

were, before the training, 311 and 156.5 kilos., respectively; after the training, 409 and 202.5 kilos., respectively. Table X gives the value of the following percentile grades: —

TABLE X. TOTAL STRENGTH.

Percentile Grade.	5.	10.	20.	30.	40.	50.	60.	70.	80.	90.	95.	Unit.
Before the training.....	176.0	191.0	201.0	213.0	221.0	230.5	243.5	264.0	277.5	293.5	310.0	Kilos.
After 7 months' Training.....	219.0	237.5	254.5	271.0	285.0	293.0	301.5	313.0	325.0	341.0	371.0	

This table shows that the total strength of the 10 per cent grade after the training (237.5) surpasses the 50 per cent grade before the training (230.5), and approaches the 60 per cent grade value (243.5). The 50 per cent value after the training (293) nearly equals the 90 per cent value before the training (293.5), and the 70 per cent value after the training (313) is beyond the 95 per cent value before the training (310).

It is of interest to study the ratio of some of the items mentioned.

Ratio of weight and height, *i. e.*, $\frac{W}{H}$ (W = weight in kilo., H = height in centimetres) expresses how much weight an individual possesses for every centimetre of his stature; for instance, $\frac{W}{H} = 0.340$, *i. e.*, 0.340 kilos. for each centimetre of stature. For the sake of convenience this ratio will be spoken of under the term *weight-height index.* Besides, we present tables indicating the influence of the training upon the following indices: —

Ratio of lung capacity (in litres) and weight $\left(\frac{L\,C}{W}\right)$, *i. e.*, vital capacity-weight index, or, for brevity's sake, *vital index.*

Ratio of total strength (kilos.) and weight $\left(\frac{T\,S}{W}\right)$, *i. e.*, *strength-weight index.*

The product obtained by multiplying vital index by strength-weight index $\left(\frac{L\,C \times T\,S}{W^2}\right)$, *i. e.*, *vital strength-weight index.*

The product obtained by multiplying vital index by total strength $\left(\frac{LC \times TS}{W}\right)$, *i. e., power index.*

The four indices last mentioned were discussed by the writer in a paper read before the American Association for the Advancement of Physical Education, at its eighth annual meeting in Philadelphia, April, 1892, entitled "Some Measurable results of Swedish Pedogogical Gymnastics," and printed in the proceedings of that Association. To this paper those are referred who are interested in a further description of the indices. Here we will only quote some of the results summed up.

1. The *vital strength-weight index* grows parallel with the growth of efficiency and adaptability to gymnastic exercises; and is indicative of the degree of an individual's training with reference to gymnastic exercises. This index becomes still more instructive in this respect if its component vital index and strength-weight index are consulted also.

2. Under ordinary circumstances those women of vital strength-weight index lower than 0.2000 are not in condition for gymnastic exercises so vigorous as climbing; those of 0.3000 or more are in excellent condition for such exercises; those between 0.2000 and 0.3000 are between unable and well-conditioned.

3. Under ordinary circumstances the *vital index* necessary for ability to climb is in the neighborhood of 0.0474, but in combination with a high strength-weight index or a very energetic moral disposition some imperfect climbing may exist with even lower vital index, and has been observed in a case with as low a vital index as 0.0444.

4. Under ordinary circumstances the *strength-weight* index necessary for ability to climb is about 5.4; but, in combination with high vital index or a very energetic disposition, climbing may be possible with lower strength-weight index, and some imperfect climbing has been observed in a case with strength-weight index only 3.6.

5. Two vital strength-weight indices of equal number may have different values, as exponents of physical efficiency, depending upon whether they are composed of a vital index and a strength-weight index of corresponding heights or of a high and a low index.

6. So far as can be judged from observation of about 100 cases, the vital strength-weight indices of women which correspond to the highest efficiency of the most manifold adaptability in the gymnasium are those composed of a strength-weight index of 6.2 or more, and a vital index of 0.0550 to 0.0600 or somewhat above 0.0600. Those composed of a low strength-weight index and a vital index considerably higher than 0.0600 (0.0650 or more) are more difficult to estimate, and their number is comparatively small.

As an illustration of the correlation between the growth of the vital strength-weight index and the growth of working capacity in the gymnasium the following table is offered. It will be understood without further explanation than to say that the marks are our subjective estimate of the capacity of the students to climb the perpendicular rope. The figures indicate the number of students who have the index as given at the top of the perpendicular column, and the mark in climbing as given at the head of the horizontal column. A^1 means excellence; C, entire inability; B^2, the first struggling success to climb a few inches upward; the other marks indicate the intermediate stages of proficiency.

TABLE XI. COMPARISON OF VITAL STRENGTH-WEIGHT INDICES AND MARKS IN CLIMBING OF 51 JUNIOR STUDENTS OF THE BOSTON NORMAL SCHOOL OF GYMNASTICS.

	0.1659–0.1999.	0.2000–0.2499.	0.2500–0.2599.	0.2600–0.2699.	0.2700–0.2799.	0.2800–0.2899.	0.2900–0.2999.	0.3000–0.3499.	0.3500–0.3999.	0.4000–0.4499.	0.4500–0.5000.	0.5000–0.5270.	Total.
A^1.....	...	....	....	*3	....	....	....	10	3	3	....	1	20
A^2.. ...	....	*2	....	*1	1	1	2	....	....	....	....	....	7
Ab^1....	....	1	2	1	2	....	....	....	....	....	....	....	6
Ab^2....	....	3	2	....	1	....	....	1	....	....	....	....	7
B^1.....	....	2	....	....	....	....	....	....	....	....	....	....	2
B^2.....	*1	2	1	....	....	....	...	....	....	....	....	....	4
C.....	4	....	....	1	....	....	....	....	....	....	....	....	5
Total...	5	10	5	6	4	1	2	11	3	3	....	1	51

Imperfect climbing under difficulty corresponds to index				0.2000–0.2500
Growing ability to climb corresponds to index			. .	0.2500–0.3000
Ease in climbing	"	" "	. .	0.3000–0.3500
Great ease in climbing	"	" "	. .	0.3500–

While the vital strength-weight index grows parallel with aptitude in such exercises as demand the weight of the body to be lifted by the individual's own muscles (as climbing, jumping, etc.), the power index shows a more marked correspondence with the growing capacity in such exercises in which outer resistance is combated. It deserves to be noted that the power index, being the product of vital index and total strength, *i. e.*, $\left(\frac{LC \times TS}{W}\right)$, is also the product of vital strength-weight index and weight, *i. e.*, $\frac{LC \times TS}{W^2} \times W = \frac{LC \times TS}{W}$

Weight-Height Index. The extreme values are, before the training, 0.454 and 0.270, respectively; after the training, 0.454 and 0.259, respectively. Table XII gives the value of the following percentile grades: —

TABLE XII. WEIGHT-HEIGHT INDEX.

Percentile Grade.	5.	10.	20.	30.	40.	50.	60.	70.	80.	90.	95.
Before the training	0.279	0.290	0.299	0.312	0.322	0.331	0.343	0.351	0.372	0.389	0.401
After 7 months' training	0.274	0.286	0.301	0.312	0.320	0.330	0.344	0.351	0.366	0.384	0.405

The general tendency has been towards a slight diminution of this index under the influence of the training.

Vital Index. The extreme values are, before the training, 0.0710 and 0.0307, respectively; after the training, 0.0720 and 0.0409, respectively. Table XIII gives the values of the following percentile grades: —

TABLE XIII. VITAL INDEX.

Percentile Grade.	5.	10.	20.	30.	40.	50.	60.	70.	80.	90.	95.
Before the training	0.0384	0.0407	0.0430	0.0456	0.0480	0.0499	0.0513	0.0536	0.0570	0.0602	0.0661
After 7 months' training	0.0438	0.0450	0.0475	0.0495	0.0506	0.0530	0.0550	0.0565	0.0590	0.0630	0.0661

Increase of this index has been the general result of the training, except in the highest percentile grades, and the increase has been greatest at the lower grades. The value at the 30 per cent grade after the training (0.0495) approaches the 50 per cent value before the training (0.0499), and the 50 per cent value after the training (0.0530) approaches the 70 per cent value before the training (0.0536).

Strength-Weight Index. The extreme values observed are, before the training, 6.4 and 2.87, respectively; after the training, 7.33 and 3.6, respectively. Table XIV gives the values of the following percentile grades: —

TABLE XIV. STRENGTH-WEIGHT INDEX.

Percentile Grade.	5.	10.	20.	30.	40.	50.	60.	70.	80.	90.	95.
Before the training.....	3.26	3.47	3.72	3.96	4.12	4.40	4.53	4.8	5.27	5.70	5.98
After 7 months' training.....	4.02	4.36	4.77	4.94	5.28	5.48	5.66	6.0	6.35	6.65	7.60

Increase of this index has taken place at all the grades. The value of the 10 per cent grade after the training (4.36) reaches nearly the 50 per cent value before the training (4.40), while the 50 per cent value after the training (5.48) is about equal to the 85 per cent grade before the training.

Vital Strength-Weight Index. The extreme values are, before the training, 0.415 and 0.108, respectively; after the training, 0.527 and 0.166, respectively. Table XV shows the values of the following percentile grades: —

TABLE XV. VITAL STRENGTH-WEIGHT INDEX.

Percentile Grade.	5.	10.	20.	30.	40.	50.	60.	70.	80.	90.	95.
Before the training..... ...	0.1290	0.1480	0.1710	0.1925	0.2050	0.2180	0.2385	0.2530	0.2730	0.3170	0.3320
After 7 months' training.....	0.1925	0.2150	0.2445	0.2575	0.2690	0.2845	0.3060	0.3325	0.3600	0.3810	0.4100

We find that the value of the 10 per cent grade after the training (0.2150) approaches the 50 per cent value before the training (0.2180), and that the 50 per cent value after

the training (0.2845) is higher than the 80 per cent value before the training (0.2730).

Comparing with the subjective estimate of ability to climb, referred to above, we find that the vital strength-weight index necessary for climbing is —

With difficulty (about 0.2000) before training at 40 per cent, after training at 10 per cent.

Ability (about 0.2500) before training at 70 per cent, after training at 30 per cent.

Ease (about 0.3000) before training at 90 per cent, after training at 60 per cent.

Great ease (about 0.3500) before training at 00 per cent, after training at 75 per cent.

Power Index. The extreme values of this index are, before training, 18.6 and 4.9, respectively; after training, 25 and 9.3, respectively. Table XVI gives the values of the following percentile grades: —

TABLE XVI. POWER INDEX.

Percentile Grade.	5.	10.	20.	30.	40.	50.	60.	70.	80.	90.	95.
Before the training.....	8.10	8.65	9.9	10.35	11.10	11.9	12.45	13.15	13.95	15.10	15.50
After 7 months' training.....	11.05	11.65	13.3	14.10	14.85	15.7	16.40	17.15	17.70	18.95	19.95

The value of the 10 per cent grade (11.65) after the training approaches the 50 per cent value before the training (11.9), while the 50 per cent value after the training (15.7) surpasses the value of the 95 per cent grade before the training (15.5).

The anthropometrical data which we have presented above justify the opinion that the susceptibility of American women to gymnastic training is considerable. The tables of strength and lung capacity, and, still better, the computed indices, the vital strength-weight index, and the power index, show that by seven months' training the mere physical working capacity of these women, such as manifests itself in gymnasium work, has grown from the 10 per cent grade to the 50 per cent grade, and from the 50 per cent grade to the 80 or 90 per cent grade.

THE GROWTH OF ST. LOUIS CHILDREN.

By William Townsend Porter.

In January, February, and March, 1892, 33,500 boys and girls in the St. Louis public schools were measured by me and my assistants. The following data were collected: Name of pupil, place of birth, age at nearest birthday, birthplace of father, birthplace of mother, occupation of father, number of brothers and sisters living and dead, residence of pupil, color of hair and eyes, height standing, height sitting, span of arms, strength of squeeze with right and left hand, girth of chest at full inspiration and full expiration, weight, acuteness of vision in right and left eyes, length of head, width of head, height of face from root of nose to point of chin, width of face, height of face from hair line to point of chin, and, finally, the school grade of the pupil.

The information thus secured has furnished material for the following publications: (1) *The Physical Basis of Precocity and Dullness*, Transactions of the Academy of Science of St. Louis, Vol. VI, No. 7, issued March 21, 1893; (2) *The Relation between the Growth of Children and their Deviation from the Physical Type of their Sex and Age*, Transactions of the Academy of Science of St. Louis, Vol. VI, No. 10, issued November 14, 1893; (3) *Untersuchungen der Schulkinder in Bezug auf die physischen Grundlagen ihrer geistigen Entwickelung*, Verhandlungen der Berliner Anthropologischen Gesellschaft, Sitzung vom 15 Juli, 1893, Virchow's Zeitschrift für Ethnologie; (4) *The Growth of St. Louis Children*, Transactions of the Academy of Science of St. Louis, Vol. VI, No. 12, issued April 14, 1894. Three other papers are in preparation: *The Growth of Large and Small Children; Acuteness of Vision in the St. Louis Public Schools;* and a statement of the normal weights for children of different heights.

I purpose in this paper to give a brief account of some of the results of these studies.

It is a matter of much interest to determine whether measurements made for the most part by teachers in the public schools are sufficiently accurate to furnish reliable physical standards. The statistician answers this question by comparing the observed distribution of the heights or weights, etc., at any age with the distribution of an equal number of observations according to the theory of probabilities. A glance at the theoretical and the observed distribution of the heights of 2192 girls, aged 8 (Table No. 7 in *The Growth of St. Louis Children*), shows a satisfactory agreement between them. This indicates that the number of measurements is so large that deviations to one side of the true height are fairly well compensated by deviations to the other side. In such a case the median value of the series is typical of the series. Thus, in this investigation measurements collected by comparatively unskilled observers were found to satisfy the requirements of theory.

The objection sometimes made that the errors of observation materially affect the truth of the values obtained is of little weight, partly because such errors are "accidental" and compensate each other, and partly because a deviation from the middle value due to an uncompensated error in measurement forms, as a rule, an inconsiderable part of that greater deviation which expresses the physiological difference between the individual and the type of his age and class. "Accidental" errors of observation need not give concern in measurements of great numbers of school children. Nor need there be much fear of constant errors of observation, provided the collection of material is made by many persons, and with a good number of each sort of measuring instrument.

The degree of deviation of individual measurements from the median value of an anthropometrical series is measured by the Probable Deviation, that value which, in the words of Lexis, is as often exceeded as attained. Hence, if Quetelet's

theory is true, the probable deviation is a measure of the degree of deviation of individuals from their physical type. The probable deviation contains the Error of Observation as well as the Physiological Difference of the individual from the type. The Error of Observation, in a large series of measurements, is insignificant. The probable deviation may therefore, without any error of importance, be considered as the physiological difference between the individual and the type.

The comparison of the probable deviations from the average height standing of the school children in the Freiburg School District (measured by Geissler and Uhlitzsch) and the St. Louis school children reveals a difference of only a few millimetres, although St. Louis children are taller than Freiburg children. It follows that the physiological difference between individual school children and the physical type of their sex and age is essentially the same where the differences between the children compared are not greater than those existing between the St. Louis and the Freiburg children.

The probable deviation at different ages is found to vary with the quickness of growth as measured by the relative annual increase of average height, weight, etc. Hence, the physiological difference between the individual children in an anthropometrical series and the physical type of the series is directly related to the quickness of growth.

It is much disputed whether median or average (arithmetical mean) should be employed as the type value. The difference between the median and the average values in this investigation is relatively small, indicating that the median value, which is obtained with comparatively little labor, may be used in place of the average, where the material is as large, and of the same nature, as that analyzed by me.

It is pointed out that the comparisons now often made between the type-children of the schools of different cities and countries cannot be justified, unless it is shown that the school populations from which these types are drawn are

sufficiently alike to be rightly comparable. Information is given concerning occupation of parents of St. Louis children.

A comparison of the weights of the daughters of manual tradesmen with the weights of the daughters of professional men and merchants teaches that the latter are very little heavier than the daughters of manual tradesmen until the period of prepubertal acceleration; and that the weight of girls is much more influenced by the material prosperity, or social status, of parents during and immediately after the period of prepubertal acceleration than in the earlier years of growth.

The nationality of the children should be considered in an anthropometrical enquiry. The weights of children of German parentage are compared with those of American parentage. The difference between the two is inconsiderable.

When the curves of growth in weight, height standing, height sitting, span of arms, and girth of chest are drawn on the same system of co-ordinates, the attention of the observer is arrested by the difference in the development of girls and boys during the period of prepubertal acceleration. Girls enter this time of rapid growth at age 11 or 12, two years earlier than boys, and during several years are larger than boys of the same age. The ages at which girls begin to be larger than boys are nearly the same in all five dimensions named above, and a similar correspondence is seen in the age at which girls cease to be larger than boys. The sexual difference just noted is not present in expansion of chest, or in strength of squeeze, or in any head or face measurement, except height of face from hair-line to point of chin. Boys have therefore a larger expansion of the chest, greater strength of squeeze, and greater length and width of head, and height and width of face than girls throughout their period of growth.

The duration of the period during which girls are larger than boys in weight, height standing, height sitting, span of arms, and girth of chest is shortest in span of arms, and is

considerably longer in height sitting than in any other dimension.

Big girls begin to be larger than big boys at an earlier age than that at which small girls begin to exceed small boys. The period in which small girls are larger than small boys is longer than that in which big girls are larger than big boys.

The absolute annual increase of height standing, weight, span of arms, height sitting, girth of chest, and strength of squeeze is greatest in girls at age 13, and in boys at age 15, nearest birthday. The relative annual increase (increase at any year divided by the average value at that year) gives a truer idea of growth than the absolute annual increase, because the latter value is entangled with the size of the individual measured. The absolute increase is commonly greater in a big boy than in a small boy, and yet the rate of growth may be the same. The relative annual increase is free of such errors. The relative annual increase in strength of squeeze, weight, height standing, height sitting, span of arms, and girth of chest is treated in Chapter VII of *The Growth of St. Louis Children.*

The ratio of span of arms, height sitting, chest girth, weight, strength of squeeze with right hand, and five head and face measurements to height standing is also given in Chapter VII. These relations are shown graphically in Plate XLV of *Growth of St. Louis Children*, height standing being expressed by an abscissa, and the percentage relation of the other dimensions to height displayed in curves. Of all these span of arms most closely approximates the height, the difference being less than one per cent of the latter from age 6 to 11, and scarcely more than two per cent in subsequent ages. The height sitting and the girth of chest run a parallel course, and are, moreover, nearly equal, the girth of chest being about two per cent less than the height sitting. They increase a little less rapidly than the height, showing a decline of about 4 per cent in thirteen years. Height sitting and chest girth are not far from half the height standing.

Far different is the development of weight and strength of squeeze. These increase much more rapidly than height, for at age 6 the height stands to weight in the ratio of 100 to 18, and to strength of squeeze as 100 to 6, while at age 16 these ratios are 100 to 34 and 100 to about 16, respectively. The parallelism in the development of weight and strength of squeeze is interesting. The dimensions of the head and face increase somewhat less rapidly than the height.

In Volume VI, No. 7, of the *Transactions of the Academy of Science of St. Louis*, issued March 21, 1893, I demonstrated that children who possess more than the ordinary power of mental labor, as measured by their progress in their studies, are heavier, taller, and larger in girth of chest and in width of head than their less gifted companions of the same age. A more extended statement of these observations was presented to the Berliner Gesellschaft für Anthropologie, Ethnologie, und Urgeschichte, July 15, 1893, and appears in *Virchow's Zeitschrift für Ethnologie*, under the title "Untersuchungen der Schulkinder in Bezug auf die physischen Grundlagen ihrer geistigen Entwickelung." In these papers the material was the total number of observations irrespective of the social condition of parents. An example, selected from Tables Nos. 2 and 4, pages 165 and 167, of *The Physical Basis of Precocity and Dullness*, will illustrate the result of the enquiry. Pupils aged 11 are found in Grades I, II, III, IV, V, and VI of the St. Louis Public Schools, as the following table shows. The 59 boys of Grade I, the lowest grade,

TABLE SHOWING MEDIAN WEIGHT OF BOYS AGED 11 DISTRIBUTED BY SCHOOL GRADE.

Grades.	Number of Boys Weighed.	Median Weight. Kilogrammes.
I	59	28.83
II	311	29.74
III	664	30.92
IV	546	31.43
V	123	32.41
VI	33	33.29

weigh less than the boys of Grade II, and these again are lighter than the boys in higher grades.

When children of the same age and, nearly as possible, of the same class of society are weighed, and the weights distributed by school grade, it is found that they follow the law established for the whole material irrespective of social condition. Tables are given in *Growth of St. Louis Children* of the weights of the daughters of manual tradesmen and of the daughters of professional men, distributed by school grade. The results of this study of the weights of girls from the same social class confirm the conclusion that successful pupils are larger than the unsuccessful.

The relation between the ability to succeed in school work and the rate of growth or yearly increase in size is treated in *The Physical Basis of Precocity and Dullness*, p. 176 *et seq.* It appears that the comparative rate of growth of dull, mediocre, and precocious children of the same sex is the same at all ages, from 7 to 16, inclusive. The data at hand were not sufficient to decide whether this law is true of other ages in the period of growth. It is further shown that the acceleration in weight preceding puberty takes place at the same age in dull, mediocre, and precocious children; and that the point in the period of accelerated development at which girls become heavier than boys is the same in the dull, the mediocre, and the precocious.

The following are among the data given in *Growth of St. Louis Children:* The median and average value of each series of observations; the probable deviation; the probable error of the average; median minus average value; relation of weight, span of arms, etc., etc., to height standing; the 5, 10, 20, 25, 30, 40, 50, 60, 70, 75, 80, 90, and 95 percentile grades; the absolute annual increase of the average; the absolute annual increase at various percentile grades; the relative annual increase; and several cranial indices.

Reprinted from the *Eighth Annual Report of the State Board of Health of Massachusetts.*

THE GROWTH OF CHILDREN.*

By Dr. H. P. Bowditch.

On the 24th of September, 1872, at a meeting of the Boston Society of Medical Sciences, a communication was made of which the following report was published in the "Boston Medical and Surgical Journal" for December 19, 1872: —

"Dr. Bowditch exhibited a diagram showing the rate of growth, in height, in the two sexes. The curves of growth were so drawn that the abscissas gave the age in years, and the ordinates the height in feet and inches. They represented the average measurements on thirteen individuals of the female and twelve of the male sex. The measurements were all taken annually during the last twenty-five years, and the individuals were all nearly related to each other. An examination of the curves shows the following facts: —

"1. Growth is most rapid during the earliest years of life.

"2. During the first twelve years boys are from one to two inches taller than girls of the same age.

"3. At about twelve and a half years of age girls begin to grow faster than boys, and, during the fourteenth year, are about one inch taller than boys of the same age.

"4. At fourteen and a half years of age boys again become the taller, girls having at this period very nearly completed their growth, while boys continue to grow rapidly till nineteen years of age.

"The tables and curves of growth given by Quetelet show that in Belgium girls are at no period of their lives taller than boys of the same age, though at twelve years of age their weight is precisely the same as that of boys, and decidedly less both before and after that period. Measurements taken among the lower classes, in Manchester and Stockport, show that, during the thirteenth and fourteenth years, girls are superior to boys of the same age, both in height and weight.

* The investigation, of which the results are given in this Report, was originally undertaken under the auspices of the health department of the Social Science Association, but in view of the extended character which the inquiry gradually assumed in its progress, and of the direct bearing of the question on the sanitary condition of the people, it was decided to make it the subject of a report to the State Board of Health.

"It would be interesting to determine, by more extended observations, in what races and under what climatic conditions the growth of girls, at about the period of puberty, is the most rapid. It is possible that in this way facts may be discovered bearing upon the alleged inferiority in physique of American women."

To explain the discrepancy thus apparent in the results of observations in different countries, a renewed investigation seemed to be necessary, and, as a contribution to our knowledge of the subject, a systematic measurement of the pupils, in the public schools of Boston, was undertaken.*

The nature and object of the inquiry are explained in the following letter, read by Dr. D. F. Lincoln at the meeting of the Social Science Association at Detroit, in 1875, with the hope of exciting an interest in the subject, which might lead to similar investigations in other parts of the country: —

"The object of ascertaining the heights and weights of the pupils in the public schools of Boston is to determine the rate of growth of the human race under the conditions which Boston presents. It is, of course, very desirable that similar observations should be made in other parts of the country, in order to enlarge the number of data from which conclusions may be drawn. This country offers an excellent field for investigations of this sort, not only on account of the wide range of climatic conditions which it presents, but from the fact that the inhabitants are the immediate descendants of a large number of different races. If we can compare, therefore, the rate of growth of a race in their native land with the rate of growth of the same race after emigration to this country, we shall be able to study the effect of transplantation into new climatic conditions; and if we compare together the amount of change which the rate of growth of different races undergoes after emigration to this country, we shall have data for estimating the relative adaptability of the races in question

* The necessary authority for the work was granted by the school committee in the following order: —

IN SCHOOL COMMITTEE, March 9, 1875.

Ordered, That permission be given to Prof. Henry P. Bowditch, of Harvard University, to ascertain the height and weight of the pupils attending the public schools, through such an arrangement as the respective chairmen and the head masters, or masters, may deem most convenient.

Attest: BERNARD CAPEN, *Secretary*.

to the new climate. Moreover, if it shall be found that the rate of growth of the female sex is more seriously modified by emigration than that of the male sex, light may be thrown on the question of the cause of the alleged inferiority of the physique of American women. As the value of observations of this sort depends entirely upon their accuracy, it is important that the height should be measured without shoes, on rods graduated to one-tenth of an inch. The weight should be determined on scales weighing pounds and ounces.

Method of Investigation.

In order to obtain the necessary data, blanks, with the following headings, were prepared and distributed to the various schools: —

Record of the Height and Weight of the Pupils in the School for , Boston, 187 .

Number.	Name.	Age.		Height without Shoes.		Weight in Ordinary Clothes.		Birthplace.	Nationality of Parents.		Occupation of Parents.	Remarks.
		Years.	Months.	Inches.	Tenths.	Pounds.	Ounces.		Father.	Mother.		

The principals of the schools were personally visited, the nature of the inquiry explained to them, and their coöperation in the work requested. It is to the friendly and intelligent interest shown by these gentlemen that the success of the work is in great measure to be attributed. The above-mentioned blanks were filled out by the various teachers for their respective classes, the weighing and measuring being done under the personal superintendence of the principals themselves, or, in a few instances, under that of a trustworthy deputy. The heights, without shoes, were measured by means of a rod graduated to tenths of an inch, and furnished with a sliding horizontal bar and a clamp, by which it could be fixed firmly to any table in a vertical position. The heights

were usually recorded at the nearest tenth of an inch, but in some instances at the nearest quarter inch. In the case of one set of papers, where they were given at the nearest inch, the observations were rejected in calculating the averages.

The weights were determined by Fairbanks' platform scales weighing to ounces; but, in view of the error necessarily introduced by the unknown weight of the clothing, they were recorded only at the nearest quarter pound. The allowance to be made for clothing in calculating the average net weight will be considered later.*

The birthplace of the pupils was recorded with the view of discriminating between native and foreign-born children, but the latter were found to be so few in number that it was thought best to disregard entirely the data of this column.

The nationality (*i. e.*, the native country) of the parents was ascertained by questioning the pupils. In a few instances where, owing to the youth or ignorance of the pupils, the result of this inquiry was unsatisfactory, the necessary information was obtained through the police. It is not to be supposed that the data recorded under this heading are absolutely accurate. There are doubtless instances where foreign-born parents are recorded as American; but this probably occurs chiefly in those instances where the parents have emigrated to this country in very early life, and have thus become completely acclimated before the birth of their children. For a thorough study of the effect of climate in modifying the rate of growth of different races, it would, of course, be important to ascertain the nationality of the ancestors of the pupils for several generations; but this inquiry seemed quite impracticable for the generality of public-school pupils, and was therefore not attempted. Data of this sort were, however,

* Notwithstanding the many advantages of the metric system of weights and measures, it was not employed in this investigation, because it was considered that, the measurements being taken by many different individuals, greater accuracy would be secured by the use of familiar units. Moreover, the general results being expressed in comparatively few figures can be readily calculated in the metric system, and thus made comparable with those of observations taken in Continental Europe.

obtained, through the kindness of Lieut. Zalinsky, from a number of the pupils in the Massachusetts Institute of Technology.

The occupation of parents was copied from the school records, with a view of ascertaining approximately the effect of the social condition of the parents on the growth of the children; but the utilization of the data thus obtained has been necessarily postponed for the present, on account of the great addition to the labor of this investigation which it would involve.

Under the head of remarks the teachers were requested to note any deformity of the pupils which might render it expedient to exclude their measurements from the calculation of a normal average. The fact of color was also noted under this heading, in order that negro and mulatto children might be distinguished from white children of American parents.

The statistical data above described were collected in nearly all the public schools of the city proper, in several schools in South Boston, Roxbury, Charlestown, and Jamaica Plain, in the Massachusetts Institute of Technology, in Mr. J. P. Hopkinson's private Latin School, in Miss Hubbard's school for young ladies, and, through the kindness of Dr. Robert Amory, in several of the public schools of Brookline. About 24,500 observations were thus collected, a number which was considered sufficiently large to justify conclusions on the subjects to which the inquiry was directed.

On the receipt of the records from the various schools the observations were at once tabulated according to the nationality of the parents, those of each nationality being arranged on a separate series of sheets, showing at a glance, in parallel columns, all the observations of any given age. The greater part of this work of tabulation was performed by Miss Mary P. Nichols, to whose accurate and patient labor the value of the results obtained is largely due. Mr. James Dike also rendered valuable assistance in this work.

In this tabulation it was important to select only those

nationalities which would give at each age a sufficient number of observations to justify the calculation of an average. The selection was of course at the outset to a great extent conjectural and tentative, and could be definitely made only as the work progressed. It was finally decided to limit the tabulation by nationality of parents to the following groups:

I. Parents, both American.
II. Parents, both Irish.
III. Parents, one American and one Irish.
IV. Parents, both German.
V. Parents, one or both English.

In the last three of these groups the observations were not sufficiently numerous to establish the rate of growth with very great precision; but the results have a certain value as approximations to the truth.

The observations thus tabulated were placed in the hands of professional accountants, by whom the average heights and weights for the different ages and nationalities were calculated both in the English and in the French systems of weights and measures. The results are given in Tables Nos. 1 and 2, at the end of this article.

It will be noticed that it has been assumed in this investigation that the rate of growth of children may be ascertained by computing at any one time the average height and weight of children of different ages, as well as by determining the average height and weight of a given set of children in successive years. This assumption is doubtless perfectly justifiable, though certain theoretical objections may be urged against it. It may be said, for instance, to involve the further assumption of the prevalence at any given time of equally favorable conditions for the growth of children of *all* ages. It is, however, conceivable that at a certain time particularly favorable or unfavorable conditions for the growth of young children may prevail, while the growth of older children may be less affected. The rate of growth determined by observations taken at this time will therefore show a deviation from

the normal type. This objection is deprived of whatever weight it may have by extending the observations over a considerable length of time. It is probable that when the investigation is carried on, as in the present instance, during the greater part of a year, the effect of such disturbing influences may be regarded as, to a great extent, eliminated, though a series of investigations undertaken at intervals of several years would be necessary to definitely settle the question. For a further discussion of this method of ascertaining the rate of growth, the reader is referred to the statistical investigations of Dr. B. A. Gould,* p. 115.

From the averages given in Tables Nos. 1 and 2, Table No. 3 was then computed, shewing the annual increase both in height and weight of children of both sexes, and of the above-mentioned parentage. In this table is also given in the columns headed "pounds per inch" a series of figures obtained by dividing the weight in pounds by the height in inches, and showing what, for want of a better word, may be called the "stoutness" of the children at different ages, etc.†

In order to obtain a more adequate idea of the growth of the children in this community than that furnished by the average heights and weights, another set of tables was computed, showing for every age the number of observations at each height and weight. Tables of this sort for children of American and of Irish parents, and for the whole number of observations irrespective of nationality, are given at the end

* Investigations in the Military and Anthropological Statistics of American Soldiers. By Benjamin Apthorp Gould. New York. 1869.

† It will be noticed that in Tables Nos. 1 and 2 the ages are given "at the last birthday." Hence, the *average age* of the children thus grouped together will be six months greater than the age given in the tables. For instance, 5 years 6 months is the average age of the 201 boys of American parentage, whose height is 41.74 inches, and whose weight is 41.20 pounds. Now, since the figures in the columns headed annual increase, in Table No. 3, are the differences between the successive heights and weights in Tables Nos. 1 and 2, it is evident that they express the yearly growth precisely at the age given in the table. For instance, if the average height of the above-mentioned boys of 5½ years old is 41.74 inches, and that of the boys of the same parentage, one year older, is 44.10 inches, then 2.36 inches is the average annual increase in height of boys at 6 years of age. On the other hand, the figures, in the columns of Table No. 3, headed pounds per inch, express (as in Tables Nos. 1 and 2) the ratio of the weight to the height of the children whose age *at last birthday* is placed opposite to them in the table.

of the article. (See Tables Nos. 4 to 15.) The observations on children of other nationalities were so few in number that it was not considered important to present them in this form. To facilitate a comparison of the distribution of the observations at different ages, a second column of figures is given under each age, showing the *percentage* of the observations occurring at any given height or weight.

A tabulation of this sort renders it possible to see at a glance the extreme range of variation of the individual observations. In the progress of the work many cases were met with of heights and weights differing so widely from the average measurements of the age to which they belonged as to excite a suspicion of error in the observation. In these cases application was made to the principals of the schools for a confirmation or a correction of the measurements. About forty errors were thus detected, the necessary corrections made, and the tables of averages made more accurate than they otherwise would have been.

RESULTS.

The results of the whole investigation are embodied in the tables at the end of the article; but, in order to facilitate their comprehension, the graphic method has been adopted for their expression, curves having been constructed which indicate at a glance the more important conclusions which can be drawn from an examination of the tables. Thus, on Plate I, the ordinates of the two upper curves express the average heights for each age of all the children measured, irrespective of the nationality of their parents, the full line representing the boys' rate of growth, and the broken line that of the girls. The two lower curves indicate the average weights in the same set of observations. The age is expressed by the row of figures on the line of abscissas, the height in inches by the column on the left (corresponding to the two upper curves), and the weight in pounds by the column on the right of the plate (corresponding to the two

lower curves). The figures at the bottom of the plate show for each age the number of observations from which the averages were computed.

Plates II and III exhibit in a similar way the rate of growth in height and weight of children of American and of Irish parentage.

The curves on these plates are less regular than those of Plate I, owing to their being constructed from a smaller number of observations; but they have the same general character. The observations on children of other than American or Irish parentage were so few in number that it was not considered important to construct curves to express the results. An examination of the figures in Tables Nos. 1 and 2 shows that the curves of growth present everywhere the same general features.

The curves on the other plates are constructed in a similar way, and will be described in connection with the subjects which they illustrate.

Comparative Rate of Growth of the Two Sexes.

An inspection of Tables Nos. 1 and 2, or of Plates I, II, and III, shows in the most conclusive manner that at about 13 or 14 years of age girls in this community are, during more than two years, both taller and heavier than boys at the same age, though before and after that period the reverse is the case. Table No. 3, giving the annual rates of growth, shows the same thing in a different way. Here we see, in the column of totals, that the greatest annual increase in height occurs for girls at 12 and for boys at 16 years of age, while the maximum increase in weight is for boys at the same age and for girls one year later than the maximum increase in height. Similar, though not identical, facts are obtained by examination of the columns in which the observations are distributed according to the nationality of the parents.

This difference in the age at which the rate of growth attains its maximum in the two sexes suggests a connection

of the phenomenon with the period of puberty which presents a similar difference in the time of its occurrence. On the principle, clearly enunciated by Carpenter * and by Herbert Spencer,† that growth and reproduction are to some extent antagonistic processes, it may perhaps be reasonably supposed that at the age at which the organism becomes potentially reproductive will not be a period of excessive growth, and an examination of the data at our disposal seems to show that this is the case. It is of course almost impossible to determine statistically the average age at which males become capable of reproduction; but for the female sex the first appearance of the catamenia furnishes a satisfactory indication that this period has been reached. Few data have been collected for determining the age at which American women begin to mensurate, but Dr. J. R. Chadwick has kindly permitted the use of his manuscript tables containing the records of observations on patients at the Boston Dispensary and the Boston City Hospital. From these records observations on 575 American-born women have been selected and arranged in the following table in such a way as to indicate whether the date of the first menstruation was given approximately or accurately: —

* "There is a certain degree of antagonism between the nutritive and reproductive functions, the one being executed at the expense of the other. The reproductive apparatus derives the materials of its operations through the nutritive system, and is entirely dependent upon it for the continuance of its function. If, therefore, it be in a state of excessive activity it will necessarily draw off from the individual fabric some portion of the aliment destined for its maintenance. It may be universally observed that, when the nutritive functions are particularly active in supporting the *individual*, the reproductive system is in a corresponding degree undeveloped, and *vice versa*." — *Principles of Physiology, General and Comparative.* Third edition, 1851, p. 592.

† The Principles of Biology. Vol. II, chap. 6.

TABLE NO. 16.

Showing the Age at which Menstruation begins in American Women.

AGE AT LAST BIRTHDAY.	NUMBER OF OBSERVATIONS.		
	Approximate.	Accurate.	Total.
10, ...	4	....	4
11, ...	18	8	26
12, ...	44	5	49
13, ...	87	20	107
14, ...	126	16	142
15, ...	96	16	112
16, ...	72	11	83
17, ...	18	6	14
18, ...	16	4	20
19, ...	4	1	5
20, ...	3	....	3
Whole number, .	488	87	575
Average age, . .	14 yrs. 5 mons.	14 yrs. 7¼ mos.	14 yrs. 5½ mos.

A comparison of these data with the figures in Table No. 3 shows that the period of rapid growth which gives to girls their temporary superiority over boys precedes the average age of puberty by at least two years, and that at the age of puberty the annual growth in height is less than at any previous period of life. Whether a similar relation prevails in other countries and in the male sex are questions to be settled by future investigations.

An examination of the curves on Plates I–III shows that the statements in regard to the rate of growth of the two sexes, made in 1872,* as the result of a very small number of observations, are fully confirmed by a more extended investigation, and that the facts announced at that time in regard to the growth in height are found to be equally true of the growth in weight. It was hoped at the beginning of this investigation that it would be possible, by comparing these observations with those taken in foreign countries, to determine how far the peculiarities in the rate of growth,

* See beginning of this article.

thus made manifest, depend upon differences of race or climate. This seemed the more desirable from the fact that, according to Quetelet, the curves of growth of the two sexes never intersect, as they are shown to do in these observations. For purposes of comparison an extract from Quetelet's tables is here given, showing the height and weight of the children of

TABLE No. 17.

Showing Height and Weight of Belgian Children of both Sexes from 5 to 18 Years of Age. (Quetelet, Anthropométrie, p. 418.)

AGE.	BOYS.				GIRLS.			
	HEIGHT.		WEIGHT.		HEIGHT.		WEIGHT.	
	Inches.	Centim.	Pounds.	Kilo.	Inches.	Centim.	Pounds.	Kilo.
5, . .	38.86	98.7	35.05	15.9	38.35	97.4	33.73	15.3
6, . .	41.18	104.6	39.19	17.8	40.58	103.1	36.82	16.7
7, . .	43.46	110.4	43.43	19.7	42.81	108.7	39.24	17.8
8, . .	45.75	116.2	47.62	21.6	44.97	114.2	41.90	19.0
9, . .	47.95	121.8	51.81	23.5	47.10	119.6	46.29	21.0
10, . .	50.12	127.3	55.55	25.2	49.17	124.9	50.92	23.1
11, . .	52.17	132.5	59.53	27.0	51.21	130.1	56.21	25.5
12, . .	54.14	137.5	63.93	29.0	53.23	135.2	63.93	29.0
13, . .	56.02	142.3	72.96	33.1	55.11	140.0	71.65	32.5
14, . .	57.84	146.9	81.80	37.1	56.94	144.6	80.01	36.3
15, . .	59.57	151.3	90.82	41.2	58.60	148.8	88.28	40.0
16, . .	61.18	155.4	100.10	45.4	59.90	152.1	95.90	43.5
17, . .	62.76	159.4	109.51	49.7	60.87	154.6	103.20	46.8
18, . .	64.17	163.0	118.80	53.9	61.53	156.3	109.71	49.8

both sexes in Belgium at the ages included in our observations. On Plate IV are given curves of growth constructed from this table, by which it will be seen that the height of girls is always less than that of boys of the same age, while the weight, though the same at twelve years of age, is less both before and after that period.

Unfortunately, observations on the size of growing girls have rarely been made in any country; and it is, therefore, almost impossible to institute the desired comparison. In anthropometrical investigations the female sex seems to have

been strangely neglected, though, in all questions relating to the growth and development of the race, its importance is at least equal to that of the male sex. The only accessible observations on girls, except those of Quetelet, seem to have been made in Great Britain. Quetelet himself quotes* the following observations made by Cowell among the lower classes of the population of Manchester and Stockport, by which it appears that the relative size of the two sexes varies very much, as in this community. The curves on Plate V show the rate of growth of the factory operatives of both sexes, the values of the ordinates being taken from the above tables. It will be seen that these curves, though rather irregular, owing to the small number of observations from which they are constructed, are very different in their character from those given by Quetelet, a discrepancy to which this author, however, does not allude.

Through the kindness of Mr. C. Roberts, of London, the writer has obtained manuscript tables showing the height and weight of children of both sexes in various classes of the community. From these records it is evident that in England girls of 13 years of age are, as a rule, taller and heavier than boys of the same age.

It must, therefore, be assumed either that children in Belgium grow in accordance with a different law from that which is found to prevail in England and with us, or that Quetelet's tables and curves do not truly represent average heights and weights. A consideration of the method by which Quetelet's results were reached renders the latter assumption not improbable. It will be noticed that Quetelet nowhere gives the number of observations on which his average results are based. He speaks, to be sure, of his investigations having extended over a quarter of a century,† and yet he accounts for the small differences between the maximum and minimum heights for the different ages (averaging

* Sur l'Homme, II, 19 and 51; Original Observations in Parliamentary Reports, 1833, XX, D 1, p. 87. † Anthropométrie, p. 178.

TABLE No. 18.

Showing Comparative Heights of English Boys and Girls in Manchester and Stockport. (COWELL.)

AGE.	Employed in Factories.						Not Employed in Factories.					
	Boys.			Girls.			Boys.			Girls.		
	No. of Obs.	Inches.	Centi-meters.	No. of Obs.	Inches.	Centi-meters.	No. of Obs.	Inches.	Centi-meters.	No. of Obs.	Inches.	Centi-meters.
9, . .	17	48.139	122.2	30	47.970	121.8	41	48.564	123.3	43	48.438	123.0
10, . .	48	49.789	127.0	41	49.624	126.0	28	50.650	128.6	38	49.371	125.4
11, . .	53	51.261	130.2	53	51.155	129.9	25	51.005	129.6	29	52.099	132.3
12, . .	42	53.380	135.5	80	53.703	136.4	20	52.962	134.5	27	53.666	136.3
13, . .	45	54.477	138.3	63	55.636	141.3	22	54.977	139.6	18	55.069	139.9
14, . .	51	56.585	143.7	81	57.745	146.7	16	56.625	144.0	16	58.226	147.9
15, . .	54	59.638	151.5	81	58.503	148.6	24	58.020	147.4	13	59.153	150.2
16, . .	52	61.600	156.5	83	59.811	152.1	16	63.201	160.5	6	58.083	147.5
17, . .	26	62.673	159.2	75	60.413	153.5	20	64.068	162.7	9	60.708	154.2
18, . .	22	63.318	160.8	65	62.721	159.3	15	69.891	177.5	2	64.750	164.5
Totals, .	410			652			227			201		

TABLE No. 19.

Showing Comparative Weight of English Boys and Girls in Manchester and Stockport. (COWELL.)

AGE.	Employed in Factories.						Not Employed in Factories.					
	Boys.			Girls.			Boys.			Girls.		
	No. of Obs.	Pounds.	Kilo-grams.	No. of Obs.	Pounds.	Kilo-grams.	No. of Obs.	Pounds.	Kilo-grams.	No. of Obs.	Pounds.	Kilo-grams.
9. . .	17	51.76	23.47	30	51.13	23.18	41	53.26	24.15	43	50.44	22.87
10, . .	48	57.00	25.84	41	54.80	24.85	28	60.28	27.33	38	54.44	24.68
11, . .	53	61.84	28.04	53	59.69	27.06	25	58.36	26.46	29	61.13	27.72
12, . .	42	65.97	29.91	80	66.08	29.96	20	67.25	30.49	27	66.07	29.96
13, . .	45	72.11	32.69	63	73.25	33.21	22	75.36	34.17	18	72.72	32.97
14, . .	61	77.09	34.95	80	83.41	37.82	16	78.68	35.67	16	83.43	37.83
15, . .	54	88.35	40.06	81	87.86	39.84	24	86.83	39.37	13	93.61	42.44
16, . .	52	98.00	44.43	83	96.22	43.62	13	110.30	50.01	6	91.16	41.33
17, . .	26	104.46	47.36	75	100.21	45.44	20	117.80	53.41	9	102.44	46.45
18, . .	22	106.13	48.12	65	106.35	48.22	14	126.30	57.27	2	122.00	55.32
Totals, .	420			651			223			201		

17.6 centimeters [6.93 in.] for males, and 19.1 centimeters [7.52 in.] for females) by the statement that his observations were limited to individuals "régulièrement construits," and that the number of persons subjected to measurement was "peu considérable."* In the introductory portion of the work he describes as follows† his method of ascertaining the proportions of the human body: "I contented myself, therefore, with measuring carefully ten individuals of each age, of the male as well as of the female sex, but choosing them in general of a form which could be regarded as regular. The averages of the different groups gave me the condition of development of man from year to year."‡ It seems, therefore, evident that Quetelet's observations were made on a comparatively small number of individuals, selected on account of their more or less close conformity to what was regarded as a normal type. No measurements seem to have been taken, except on persons having a "regular form." This determination of the normal type in advance of the measurements must, of course, have been largely a matter of conjecture, and might well have led to the rejection of perfectly healthy and normal individuals whose dimensions did not correspond to a preconceived idea of the typical man or woman. It is therefore probable that if Quetelet's observations had been more numerous and less selected it would have been found that the curves of growth of the two sexes in Belgium intersect each other much in the same way as in England and in this community.

This view derives confirmation from the admission of Quetelet,§ that the growth of any one individual is far from being as regular as that indicated by the table of averages.

* Anthropométrie, p. 182.

† Anthropométrie, p. 24.

‡ As a reason for being satisfied with so small a number as ten observations he states that, on dividing the measurements made on thirty individuals into three groups of ten each, so chosen that the average *heights* for all three groups were about alike, he found that the other average measurements of these three groups differed from each other less than might have been expected in three successive measurements made on the same individual.

§ Anthropométrie, p. 183.

He writes: "There are always in the development of an individual periods of slow as well as of rapid growth. These anomalies are to be observed about the age of puberty, and especially as the result of diseases. The perfectly normal development of all the physical faculties would require a rare combination of favorable circumstances. In dealing with a large number of individuals, these little anomalies disappear in the general average, and the deficient development of one individual is balanced by the excessive growth of another; at least this is what experiment tends to teach us."

In referring to the rate of growth of a boy whose height had been annually recorded, he writes: "It will be noticed that the development was very rapid in the early years of life; then there were slight irregularities of growth between the ages of eight and fifteen years. At this latter period a rapid increase of height took place; and I have noticed the same thing in the case of my son. This increase preceded the age of puberty. Something of the same sort is to be observed in the case of girls, but here it occurs a year or two earlier. It seems, however, that there is nothing constant in the matter; hence these periods of retarded and accelerated growth balance each other to a certain extent, and leave but slight trace of their passage." It seems, therefore, that the period of rapid growth preceding the age of puberty had, in individual cases, attracted Quetelet's attention, though he found no trace of it in his tables of averages, and was inclined to regard it as a pathological result of civilization.* Inasmuch, however, as the phenomenon has in this community and in England been found to be sufficiently constant and sufficiently marked to impress itself upon the curves representing the averages of large numbers of measurements, it seems reasonable to conclude that if similar methods of investigation (viz., measuring large numbers of individuals and rejecting none except for manifest deformity) had been adopted in Belgium, similar results would have been reached.

* Du Systéme Social, p. 24.

The curves of growth of the two sexes being recognized as so distinctly different, it is of interest to inquire what practical application can be made of the knowledge thus acquired. The first question which suggests itself is: How far should this difference in the rate of growth be allowed to modify the system of mental training to which the children of the two sexes are subjected? The physical conditions upon which the manifestation of mental activity depend are too little understood, and the whole question is too complicated to be discussed in this connection, but it seems to be almost self-evident that at those periods when the forces of the organism are engaged in producing rapid growth and development of the physique, the requirements in the way of mental effort should be reduced. The fact that these periods occur at different ages in the two sexes may therefore be regarded as an argument against the co-education of boys and girls, except during the earlier years of life in which rates of growth are practically the same, *i. e.*, up to ten or eleven years of age. How much importance is to be attached to this argument is a question which demands for its solution an extended series of observations on the annual growth in height and weight of a large number of individuals, taken in connection with a record of their mental progress.

Effect of Race on Size and on Rate of Growth.

An examination of Tables Nos. 1 and 2 shows that boys and girls of American parentage are, almost without exception, both taller and heavier than children of the same age and sex whose parents are of other nationalities. The curves on Plates VI and VII illustrate this fact for children of American and Irish parents. It has not been thought desirable to construct curves for the other nationalities, owing to the irregularities which they would necessarily present in consequence of the small number of observations.

In considering this result the question naturally suggests itself, How far are the superior dimensions of children of

American parentage dependent upon differences of race and stock, and how far are they due to other conditions accidentally associated in this community with these differences? Owing to the fact that emigrants to this country belong almost wholly to the poorer classes of the communities from which they come, it is evident that in this city children of American parents must belong to families of greater average wealth, and live, therefore, in greater comfort than children whose parents were born in foreign countries. It is important, therefore, to inquire what effect comfort and misery have upon the growth and development of the human race. Most of the investigations bearing directly upon this point have reference to the influence of these conditions on the size of the full-grown individual, and not on that of growing children. Thus Villermé* concludes, as the result of his investigations, that "the stature is greater and the growth sooner completed, all other things being equal, in proportion as the country is richer and the comfort of its inhabitants more general." On the other hand, Boudin,† from an examination of the measurements of recruits to the army in different departments of France, arrives at the conclusion that stature is, to a great extent, "independent of comfort and misery, and is, on the contrary, closely connected with race." Villermé's results, as far as the duration of the period of growth is concerned, have also been disputed by Dr. Gould,‡ who has shown most conclusively that in the United States, where "misery, in the sense of excessive poverty, affecting the supply of nutriment, physical protection from the weather and needful rest, hardly exists, the epoch of full development appears to be later than in any other country," the maximum height being attained between the thirty-first and thirty-fourth years. The effect of privations and exposure in preventing the attainment of

* Quoted by Dr. Gould. Investigations in the Military and Anthropological Statistics of American Soldiers. U. S. Sanitary Commission, p. 120.

† Recueil de mémoires de Médecine, de Chirurgie et de pharmacie militaires. Paris, 1863. Vol. IX, p. 181.

‡ Loco citato.

the normal height is, however, clearly pointed out by this writer,* and is regarded by him as the cause of the small stature of sailors as compared with that of soldiers of the same age and state of enlistment. A similar conclusion in regard to the age at which the full stature is attained has been reached by Dr. Baxter,† as the result of an examination of the records of the Provost-Marshal-General's Bureau. It would, however, be manifestly unsafe to argue with this writer‡ that "if comfort and plenty do not hasten growth, but, on the contrary, coexist with an unusually tardy and prolonged development of it, as is shown to be the case in the United States, it is fairly to be inferred that they exert little if any influence in increasing the stature"; for a prolongation of the period of growth must necessarily result in an increased stature unless the *rate* of growth is at the same time proportionately diminished, and that comfort and plenty should have the latter effect is not only in itself highly improbable, but is opposed to such evidence as we have on the subject. Moreover, Dr. Baxter has himself shown§ that of the 501,068 individuals, the records of whose examinations are preserved in the Provost-Marshal-General's Bureau, the natives of the United States are taller than those of any other country. He calls attention‖ also to the fact that natives of foreign countries enlisting in the United States have a greater average height than natives of the same countries enlisting at home. He is inclined, however, to explain this circumstance by a difference in the average age of the individuals measured; but Dr. Gould¶ has shown that, making allowance for differences of average age and of minimum limit of stature for military service, in different countries, the conclusion is unavoidable that natives of European countries who enlist in America are, on the average, taller than those who enlist at home. In searching for the causes which give to Americans, and even to persons growing up in America, though not born there, this superiority of stature, it seems not unreasonable

* Op. cit., p. 132. † Statistics Medical and Anthropological. Washington, 1875.
‡ Op. cit., p. 20. § Op. cit., p. 23. ‖ Op. cit., p. 16. ¶ Op. cit., p. 180.

to attribute a certain importance to the greater average comfort of the inhabitants. The prolonged period of growth in this country is certainly not to be regarded as an argument against this view, for, in the absence of any evidence of a diminished rate of growth, this may well be regarded as a result of abundant nutrition.

Statistics from which evidence can be drawn as to the effect of comfort and misery on the size of growing children are not numerous. The observations of Quetelet, Villermé, and Cowell * seem to show that in a given community the children of the wealthier classes are, as a rule, larger than those of the poorer classes. The following table, for which I am indebted to the kindness of Mr. Roberts, throws light upon this question.

An examination of this table shows that children of the laboring classes, inhabiting towns, are, at all ages, decidedly shorter than the children of the non-laboring classes attending public schools and universities, the difference attaining a maximum of over four inches at thirteen years of age. The difference of weight is also, as a rule, decidedly in favor of the non-laboring classes, the exceptions being chiefly between the ages of eighteen and twenty-one. These facts are rendered apparent by the curves constructed on Plate VIII.

In searching for the cause of this great disparity in size, it is to be noticed, in the first place, that the laboring classes in the above table are taken from the town population only, while in the case of the non-laboring classes no such restriction is observed. In the absence of exact information as to the way in which these statistics were obtained, it is difficult to draw positive conclusions, but it is probable that the influences which tend to produce a physical degeneration of urban populations † exhibit here their effect upon the size of growing children. This tendency of city life depends upon the fact that, in the struggle for existence, physical vigor plays in cities a less decisive part than in the country, owing

* Ludwig: Physiologie, II, 717.

† See De Candolle's Histoire des Sciences et des Savants, p. 368.

TABLE NO. 20.

Showing Average Height and Weight of English Boys. (ROBERTS.)

AGE AT LAST BIRTHDAY.	LABORING CLASSES, TOWN POPULATION ONLY.				NON-LABORING CLASSES, PUBLIC SCHOOLS, UNIVERSITIES, ETC.			
	HEIGHT WITHOUT SHOES.		WEIGHT IN ORDINARY CLOTHES.		HEIGHT WITHOUT SHOES.		WEIGHT IN ORDINARY CLOTHES.	
	No. of Observations.	Inches.	No. of Observations.	Pounds.	No. of Observations.	Inches.	No. of Observations.	Pounds.
5, . .	175	41.15	175	44.20	....	....	....	....
6, . .	387	43.18	327	49.68	....	....	....	....
7, . .	581	45.15	581	51.89	3	46.10	4	50.16
8, . .	670	46.81	675	55.15	16	47.66	18	56.40
9, . .	823	48.82	851	60.58	61	50.30	60	61.96
10, . .	749	50.28	829	64.59	235	52.65	238	67.22
11, . .	621	51.83	784	69.00	430	53.93	429	73.31
12, . .	495	53.02	490	72.78	745	55.90	747	78.96
13, . .	336	54.24	336	77.38	969	58.30	974	85.27
14, . .	771	56.37	771	89.39	990	60.27	992	96.40
15, . .	1,465	59.81	1,465	100.66	819	63.00	820	107.25
16, . .	531	63.45	529	114.55	462	65.34	462	115.96
17, . .	788	65.50	773	130.45	313	66.91	317	131.93
18, . .	1,209	66.00	1,203	139.50	300	67.38	296	136.68
19, . .	937	66.50	937	143.00	344	67.74	344	142.00
20, . .	145	67.00	145	146.55	262	68.09	260	145.23

to the greater number of sedentary occupations and trades there presenting themselves, which, for their successful prosecution, neither demand nor favor a full development of the physique. It is difficult to decide how much importance should be attached to this consideration in the present case; but it must be borne in mind that wealth implies ability to choose one's occupation, and that, in England at least, an occcupation exclusively sedentary is rarely adopted except from necessity. Hence, if the term "comfort" be used to include all the favorable conditions, alimentary, hygienic, etc., which can be secured by wealth, it seems fair to conclude that, in view of the stationary character of the English population, and of the small variety of climatic conditions to which it is exposed, the above-mentioned disparity in size must be mainly due to the greater comfort enjoyed by the non-laboring classes.

If this view is correct, it seems reasonable to suppose that the difference in size between Boston school children of American and those of Irish parentage may be, to some extent, dependent upon the greater comfort and luxury in which the former live and grow up. Whether the whole difference can be thus accounted for, or whether some other agency is concerned in bringing about this result, is a question which must be next considered.

We have already seen that, according to Dr. Baxter's and Dr. Gould's investigations, the average height of the *adult* native American is greater than that of the native of any other country, and that natives of other countries growing up in America acquire a greater height than natives of the same countries growing up at home. We must now inquire whether similar conclusions can be reached in regard to the size of *growing children;* and in order to eliminate the effect which comfort and misery may have on the rate of growth, it is important to select for comparison sets of observations made upon children belonging to corresponding classes in the communities in which they live. If a comparison is made

between the children of the non-laboring classes in the English public schools and universities (see Table No. 20) and the Boston school boys of American parentage (see Table No. 1), it will be seen that there is very little difference in the heights of the two sets of boys, and that the curves of growth, if constructed on the same sheet, would intersect each other at seven different points, and be nearly coincident through their whole course. In regard to weight the American boys are up to twelve years of age lighter, from twelve to seventeen years heavier, and then again lighter, than English boys of the same ages. It is, however, manifest that the boys whose dimensions are thus compared cannot be regarded as belonging to corresponding classes in their respective communities; for there are, doubtless, a large number of native Americans to be found in the laboring classes of this city. In order to obtain a set of observations more comparable to those made on the children of the non-laboring classes in the English public schools and universities, the following table has been

TABLE NO. 21.

Showing Average Height and Weight of Boston School-boys of American Parentage Attending Public Latin School, Private Latin School, and Massachusetts Institute of Technology.

Age at Last Birthday.	No. of Observations.	Height without Shoes.		Weight in Ordinary Dress.	
		Inches.	Centimeters.	Pounds.	Kilograms.
9,	2	52.00	132.1	60.1	27.27
10,	19	53.51	135.9	70.6	32.03
11,	17	54.90	139.4	75.3	34.16
12,	28	56.78	144.2	85.9	38.97
13,	41	59.60	151.4	94.4	42.83
14,	49	61.51	156.3	99.9	45.32
15,	46	64.20	163.1	116.0	52.62
16,	40	65.83	167.2	125.8	57.06
17,	32	67.44	171.3	135.2	61.31
18,	29			138.2	62.69
Total,	303				

prepared by bringing together the measurements of the pupils of American parentage attending the public Latin School, the Massachusetts Institute of Technology, and the private Latin School of Mr. J. P. Hopkinson. It is believed that these pupils represent a class in the community corresponding sufficiently well in social condition to that class in England which sends children to the public schools and universities. A comparison of the two sets of figures shows the superiority of the American boy both in height and weight.* The difference is rendered at once apparent by an inspection of the curves on Plate IX. It seems, therefore, that there are influences prevailing in this community, other than those connected with the comfort or misery of existence, which give to a growing boy a greater height and weight than are attained by an English boy of the same age. While, therefore, the conclusions of Gould and of Baxter, as to the superior height of the adult native American, are found to be equally applicable to growing children, we find also here evidence that this superiority of stature is not dependent *solely* upon the more abundant distribution of the comforts of existence in this country, though for the reasons given above (p. 295) it seems probable that the difference is to be *partly* accounted for in this way.

In view of this result it is reasonable to assume that the superior size of children of American parentage in the Boston schools is due in part to the greater comfort in which they live and grow up, and in part to other conditions which may be described collectively as differences of race or stock. To which of these agencies in bringing about the result the greater importance is to be attributed is a question which we are at present without the means of deciding. Some light might be thrown upon the subject by tabulating the observations for each nationality according to the occupation of the

* In confirmation of this result it is interesting to note the statement made to the writer by a lady of his acquaintance, that London dealers in ready-made children's clothing recommend to American customers sizes adapted to English children one year older than those for whom the garments are purchased.

parents, and it is possible that at some future time, should circumstances favor the undertaking, the data now on hand may be utilized in this way.

The curves showing the rate of growth of the above-mentioned selected American boys have been introduced into Plate VI for comparison with the curves corresponding to the observations on children of American and of Irish parentage. It is evident that the superior size of these boys, in comparison with the average boys of American parentage attending the public schools, cannot be attributed exclusively to either of the factors which have been recognized as influencing the dimensions of growing children; for in the first place the comfort in which the pupils of these selected schools live and grow up must be greater than that enjoyed by the *generality* of children of American parentage attending the public schools; and in the second place, their ancestors for several generations are probably, in the majority of cases, American; while the children with whom they are compared, though of American parentage, doubtless have, in a great many instances, foreign grand-parents. Hence, whatever tendency residence in America may have to increase the size of growing children will, in their cases, be intensified by transmission through several generations.

The characteristics which distinguish the various races of men result from slow modifications of a common ancestral type by the action through successive generations of the varying conditions under which growth and development take place. It is therefore interesting to inquire how *quickly* the type of a race may be altered by a change in the external conditions of development. We have already seen that, as far as the height of the adult individual is concerned, a single generation is, according to Dr. Gould, sufficient to produce a marked effect. A most striking proof of this statement is afforded by the tables given by this writer,* showing that natives of New England and New York enlisting in the

* Op. cit., pp. 126, 127.

Western States have, at all ages from eighteen years upwards, a greater average height than natives of the same regions enlisting at home, thus approximating to the stature of the natives of those States where they grew up and enlisted. It was hoped at the beginning of this inquiry that it might be possible to ascertain whether local conditions have a similar effect on the size of growing children, but it has been found impossible to collect data which will warrant any positive conclusions on this subject. The only foreign nation largely represented in this community is the Irish; and all attempts by correspondence with English statisticians to discover any record of observations on the size of Irish children in their native country have been unavailing. A comparison may be instituted between the children of the laboring classes in England (see Table No. 20) and those of Irish parentage in this community (see Table No. 1); and the difference shown by the curves on Plate X is, as far as height is concerned, in favor of the Boston children; while in regard to weight the English children are at first heavier, then lighter, and then again heavier than Boston children of the same ages. Conclusions as to the effect of climatic conditions on the size of growing children could, however, be drawn from this comparison only on the assumption, first, that among the laboring classes the size of Irish children does not differ greatly from that of English children; secondly, that the children of Irish parents in this community belong wholly, or in a large proportion, to the laboring classes; and, thirdly, that the condition of the laboring classes in this community is comparable, as to comforts of life, with that of the laboring classes of England. None of these assumptions can be safely made, and it must therefore remain doubtful to what cause the difference of size between the two sets of children (amounting at thirteen years of age to over two inches in height) is really to be attributed.

A comparison between the heights of boys of German parentage in this city and that of growing boys in German

cities is not without interest. The following table shows in parallel columns the heights of boys measured in Berlin by Schadow, and of boys measured in Cologne by Angerstein, compared with the heights of boys of German and American parentage attending the schools of this city. The curves on Plate XI have been constructed from the figures of this table (the curve of growth of children of American parents being omitted in order not to confuse the diagram). It will be noticed that while the curves of growth of boys living in the German cities indicate a great difference in the rate of increase before and after eleven years of age, the rate of growth of boys of both German and American parentage in this city is much more uniform throughout the whole growing period.

TABLE No. 22.

Showing Comparative Rate of Growth of American and German Boys.

GE.	BERLIN. (SCHADOW.)		COLOGNE. (ANGERSTEIN.)		BOSTON.			
					GERMAN PARENTAGE.		AMERICAN PARENTAGE.	
	Inches.	Centim.	Inches.	Centim.	Inches.	Centim.	Inches.	Centim.
5, .	43.24	109.8	.....	.....	41.08	104.3	41.74	106.0
6, .	45.32	115.1	.....	.....	43.50	110.5	44.10	112.0
7, .	46.34	117.7	46.31	117.6	45.25	114.1	46.21	117.4
8, .	47.35	120.3	47.83	121.5	47.13	119.7	48.16	122.3
9, .	48.40	122.9	48.90	124.2	48.85	124.1	50.09	127.2
10, .	49.38	125.4	50.43	128.1	51.21	130.1	52.21	132.6
11, .	51.45	130.7	51.97	132.0	52.92	134.4	54.01	137.2
12, .	54.57	138.6	54.54	138.5	54.55	138.6	55.78	141.7
13, .	57.65	146.4	58.67	149.0	56.70	144.0	58.17	147.7
14, .	60.71	154.2	61.77	156.9	59.14	151.2	61.08	155.1
15, .	65.91	167.4	64.34	163.4	62.06	157.6	62.96	159.9
16, .	.....	.....	65.88	167.3			65.58	166.5
17, .	.....	.....	66.40	168.6	64.75	164.4	66.29	168.4
18, .	.....	.....	66.91	169.9			66.76	169.5

The figures in the above table, representing the heights of Berlin and Cologne boys, though apparently averages of a number of observations, are really more of the nature of estimates. This is evident from an examination of the original

tables as given by Angerstein,* where the heights for each age are, in most instances, expressed in an even number of German inches. Moreover, the observations on boys of German parentage in this city are few in number (752 of all ages), and there has been no attempt to distinguish between natives of different parts of Germany. It is therefore impossible to draw positive conclusions on the subject, but the evidence, as far as it goes, seems to indicate that even in the first generation after emigration the rate of growth has been modified by new external conditions.

Relation of Height to Weight.

The data collected in this investigation afford the means for ascertaining the relation of height to weight in growing children of both sexes and of various races. This relation is for each age most simply expressed by the quotient of the weight in pounds divided by the height in inches. Series of quotients thus obtained are given in Table No. 3, in the columns headed "pounds per inch." Since, however, these quotients increase with the increasing height,† it is manifestly impossible to use them for ascertaining the relative stoutness of children who at a given age differ from each other in stature. To do this with absolute accuracy it would be necessary to determine for each age, and in each set of observations, the average weight corresponding to each height. Since, however, the direct determination of this value would necessitate a complete retabulation of all the observations, it has been thought best to adopt an indirect and somewhat less accurate method of getting at the result. This method consists in arranging the heights and weights corresponding to each age opposite to each other in parallel columns, and then

* Duetsche Turnzeitung, 1864, p. 326.

† Uniform growth in all dimensions would of course cause the weights of growing children to vary as the cubes of the heights, but since growth is more rapid in the vertical than in the lateral dimensions the weights increase approximately as a lower power of the heights. A logarithmic equation, however, as given in the appendix to this article, expresses the relation much more accurately. For a discussion of the question the reader is referred to the works of Quetelet and Gould.

determining by interpolation the weights corresponding to each even inch of height.*

The results of this calculation are given in Tables Nos. 23 and 24, which show for every inch of height the corresponding weight of growing children of both sexes and in various conditions of life.

TABLE NO. 23.

Showing Relation of Height to Weight in Growing Boys. (Weight given in Pounds.)

HEIGHT, inches.	BOSTON SCHOOL BOYS.						ENGLISH BOYS.		Latin School, Technology Institute, etc.
	PARENTAGE.					Totals.			
	American.	Irish.	American and Irish.	German.	One or both English.		Laboring.	Non-laboring.	
42	41.63	42.07	41.68	41.90	41.40	41.77	46.50	.....	.....
43	43.29	43.87	43.63	43 38	43.59	43.60	49.18	.....	.....
44	44.98	45.76	45.64	45.49	45.60	45.63	50.58	.....	.....
45	47.00	47.69	47.68	48.41	47.24	47.58	51.71	.....	.....
46	49.03	49.83	49.72	50.64	49.25	49.65	53.55	.....	.....
47	51.45	52.34	51.76	52.67	51.97	52.07	55.63	53.77	.....
48	54.03	54.84	54.05	55.64	54.60	54.57	58.35	57.12	.....
49	56.81	57.48	56.52	58.59	57.49	57.31	61.10	59.23	.....
50	59.69	60.31	59.75	61.09	60.32	60.20	63.82	61.34	.....
51	62.82	63.29	63.32	63.41	63.24	63.23	66.79	63.53	.....
52	65.95	66.28	66.47	66.30	65.71	66.27	69.52	65.74	60.10
53	69.11	69.27	69.35	69.42	67.85	69.20	72.70	68.86	67.03
54	72.33	72.77	72.30	73.45	71.82	72.73	76.46	73.50	72.24
55	76.55	76.41	75.28	77.41	75.94	76.44	81.70	76.36	75.86
56	80.66	80.19	78.82	81.16	80.98	80.24	87.22	79.21	81.44
57	84.12	84.00	82.67	84.93	85.44	84.04	91.41	81.86	86.58
58	87.58	87.85	86.65	88.63	88.48	87.86	94.68	84.51	89.55
59	91.34	91.69	90.73	92.32	91.52	91.58	97.95	89.16	92.70
60	95.20	96.20	.....	97.26	95.26	95.51	101.35	94.84	95.55
61	98.94	100.50	.....	102.10	99.25	100.54	105.10	99.22	98.41
62	105.06	104.71	.....	107.23	105.41	105.63	108.99	103.23	102.79
63	111.03	108.56	.....	.....	113.24	110.71	112.88	107.25	108.75
64	115.97	112.52	.....	.....	.....	115.86	118.84	110.90	114.71
65	120.84	.....	.....	.....	.....	121.01	126.47	114.65	120.90
66	126.70	.....	.....	.....	.....	126.61	139.50	122.66	126.94
67	.....	.....	.....	.....	.....	136.09	146.55	132.88	133.64
68	.....	.....	.....	.....	.....	.....	.....	144.37	.....

* This method is defective, first, because it does not take into account the possible influence of age upon the ratio of a given height to its corresponding weight; and, secondly,

TABLE NO. 24.

Showing Relation of Height to Weight in Growing Girls. (Weight given in pounds.)

HEIGHT, inches.	BOSTON SCHOOL GIRLS.					
	PARENTAGE.					Totals.
	American.	Irish.	American and Irish.	German.	One or both English.	
42, ...	40.77	41.02	41.39	40.76	40.74	40.89
43, ...	42.61	42.70	42.77	42.50	42.79	42.62
44, ...	44.44	44.67	44.38	44.42	44.64	44.53
45, ...	46.25	46.71	46.08	46.43	46.67	46.45
46, ...	48.16	48.80	47.98	48.34	48.85	48.51
47, ...	50.47	50.96	50.23	50.29	51.02	50.71
48, ...	52.78	53.38	52.70	53.37	53.19	53.19
49, ...	55.68	56.01	55.30	56.69	55.25	56.06
50, ...	58.70	58.59	57.92	58.64	57.96	58.75
51, ...	62.02	61.10	60.71	60.83	61.04	61.39
52, ...	64.76	64.14	63.56	64.93	64.32	64.36
53, ...	67.85	67.39	66.51	69.09	67.66	67.54
54, ...	70.92	70.99	70.30	73.08	70.97	71.01
55, ...	74.14	74.65	74.89	76.90	74.33	74.90
56, ...	77.46	78.74	78.77	80.06	77.78	78.82
57, ...	80.79	82.97	82.71	83.18	82.81	83.38
58, ...	86.55	87.56	87.20	86.56	87.86	87.92
59, ...	92.64	92.86	94.60	93.32	92.80	93.29
60, ...	98.49	98.04	101.80	.....	97.86	98.81
61, ...	105.44	107.83	109.04	.....	106.14	105.39
62, ...	115.75	115.82	.....	.....	110.75	115.69

The following conclusions may be drawn from an examination of the tables: —

because it rests upon the assumption that the average weight for a given age is the same as the average weight of all individuals, without regard to age, whose height is equal to the average height for that age. This assumption clearly involves a trifling error, for, since the weights of growing children increase approximately as the 2.7 powers of the heights, it is evident that at any given age the weight of those children who are above the average height will tend to raise the average weight for that age more than the weights of the children below the average height will tend to lower it, supposing the observations to be uniformly distributed on both sides of the average according to the binomial curve of Quetelet; consequently, the average weight for a given age will be somewhat greater than the average weight of all the individuals, regardless of age, whose height is equal to the average height for that age. Notwithstanding these defects, the method has been adopted, first, because it is believed that the errors involved are so small as to be of no practical importance; and, secondly, because relative rather than absolute values were sought, and a comparison between several sets of observations is not prevented by a small constant error running through them all.

I. Growing boys are heavier in proportion to their height than growing girls until the height of 58 inches (147.9 c.m.) is reached. Above that point the reverse is the case. This is true in all the various sets of observations. The fact is rendered apparent by the curves on Plate XII, where the ordinates represent the weight in pounds corresponding to each inch of height, the values being calculated from the average dimensions of all the Boston school children measured, irrespective of the nationality of the parents. The height of 58 inches is attained in the 14th year, and it seems probable that the reversal in relative proportions of the two sexes may be connected with the accumulation of adipose tissue which occurs in girls at about the period of puberty.

II. The difference between children of American and those of foreign parents is constant in one direction for all ages, only in the case of boys of German parentage. These, as will be seen by the curves on Plate XIII, are uniformly heavier in proportion to their height than the sons of American-born parents.

III. The children of the laboring classes in England are, as shown by the curves on Plate XIV, decidedly heavier in proportion to their height than those of the non-laboring classes. This fact, taken in connection with the differences in absolute height and weight of the same children (as shown by the curve on Plate VIII), seems to indicate that deprivation of the comforts of life has a greater tendency to diminish the stature than the weight of a growing child.

IV. A comparison of the pupils of the selected Boston schools above mentioned with the children of the English non-laboring classes at the public schools and universities shows that the former are in general heavier, in proportion to their height, than the latter (see Plate XV). It seems, therefore, that the influences above alluded to (p. 297), which give to a growing boy in this community a greater height and weight than are attained by an English boy of the same age, affect the weight more powerfully than the height, and that

the Boston boy is therefore by no means to be described as tall and thin in comparison with his English cousin. Dr. Baxter's conclusion, "that the mean weight of the white native of the United States is not disproportionate to his stature"* seems, therefore, as far as these boys are concerned, as applicable to growing children as to adults.

It will thus be seen that the theory of the gradual physical degeneration of the Anglo-Saxon race in America derives no support from this investigation.†

Distribution of Observations.

Tables Nos. 4 to 15, inclusive, show the distribution of the observations on both height and weight. For instance, from Table No. 4 it will be seen that of the 848 boys of five years of age whose heights were measured four (or 0.47 per cent of the whole number) were between 47 and 48 inches high, 190 (or 22.4 per cent of the whole number) were between 41 and 42 inches high, etc. The distribution of observations on both sides of the average height or weight may be represented, according to Quetelet, by the binomial curve. That is, if the individuals measured are sufficiently numerous, it will be found that the number of observations at each successive inch (or pound) will first increase and then diminish in the same way as the successive coefficients of $(a+b)^n$, as determined by Newton's binomial theorem. It will be noticed that the figures in the above-mentioned tables do not increase and diminish with the regularity which a conformity with this law demands; but it must be borne in mind that the observations at each age are comparatively few in number, and that more numerous measurements or a distribution of the present observations in larger groups (*e. g.*, of two inches, or of eight pounds each) would doubtless cause the appearance of a closer agreement with the law.

These tables (Nos. 4 to 15) show at a glance the range of

* Op. cit., p. 55.

† See an article on this subject by Rev. A. A. Livermore, in the February number of the "Unitarian Review and Religious Magazine."

variation in height and weight at each age. It will be noticed that the range gradually increases with age (except where the whole number of observations is comparatively small), while the percentage of observations at the average height or weight, as a rule, diminishes. The most remarkable instances of variation from the normal dimensions are those of a boy five years old, and but thirty inches in height, and of three girls, 14, 16, and 18 years of age, weighing upwards of two hundred pounds.

Weight of Clothes.

It will be noticed that in this investigation the weight of the children has been given "in ordinary clothes," and no attempt has been made to ascertain the net weight by making an allowance for the clothing. This course was adopted because most of the observations with which comparisons were to be made had been taken in this way, but in order to facilitate a comparison of these records with others, in which a deduction is made for the weight of the clothes, an effort has been made to determine the average weight of the ordinary in-door clothing of children of different ages. For this purpose 317 pupils of both sexes, of various ages, and living in several different quarters of the city, were requested by the principals of their respective schools to ascertain and to report the weight of the garments worn at the time the observations were taken. From the data thus collected at various seasons of the year the following table has been computed, showing in parallel columns, for each age, the number of observations, the average gross weight of the pupils, the average weight of the clothes, and the percentage weight of the clothes referred to the gross weight of the individual. From this table it will be seen that, except in the case of very young children, both the absolute and the percentage weight of the clothing is, at any given age, greater for boys than for girls. The average weight of the clothes for all ages is for boys 8 per cent, and for girls 6.8 per cent of the gross weight.

TABLE No. 25.

Showing Average Weight of Clothes Worn by School Children.

AGE AT LAST BIRTHDAY.	BOYS.				GIRLS.			
	No. of Observations.	Average Weight in Pounds.		Percentage weight of clothes.	No. of Observations.	Average Weight in Pounds.		Percentage weight of clothes.
		Gross weight.	Clothes.			Gross weight.	Clothes.	
5, . .	5	44.22	2.85	6.45	8	41.84	2.84	6.79
6, . .	14	43.51	3.13	7.19	9	43.90	2.90	6.61
7, . .	22	52.79	3.44	6.52	20	47.82	3.59	7.51
8, . .	13	56.15	4.06	7.23	21	53.69	3.51	6.54
9, . .	12	59.85	4.76	7.95	17	61.07	4.23	6.93
10, . .	9	63.25	5.72	9.04	20	66.45	4.54	6.83
11, . .	4	67.69	6.69	9.88	17	70.97	4.88	6.88
12, . .	11	78.29	7.27	9.29	15	82.97	5.64	6.80
13, . .	12	88.19	7.40	8.39	11	96.88	5.66	5.85
14, . .	17	99.22	8.09	8.15	14	111.47	7.54	6.76
15, . .	10	103.65	8.08	7.80	13	107.23	7.85	7.32
16, . .	7	120.30	9.67	7.86	8	117.16	8.09	6.90
Total, .	136	.....	....	....	181	.....	....	....
Average for all ages,	....	.....	....	7.99	....	.....	....	6.81

This estimate is considerably larger than that given by Quetelet,* whose allowance for clothing is for boys $\frac{1}{18}$ (5.5 per cent), and for girls $\frac{1}{24}$ (4.17 per cent) of the gross weight. This difference is, perhaps, to be in part accounted for by the fact that the pupils whose clothes were weighed were probably rather better clothed than the average children of the same age; for it was, of course, impossible to obtain, by the method adopted, any data from the poorest classes of the population, owing to their lack of an intelligent interest in the matter.

* Sur l'Homme, II, p. 44.

Summary of Results.

The most important results of the foregoing investigation may be enumerated as follows: —

I. The growth of children takes place in such a way that until the age of eleven or twelve years boys are both taller and heavier than girls of the same age. At this period of life girls begin to grow very rapidly, and for the next two or three years surpass boys of the same age in both height and weight. Boys then acquire and retain a size superior to that of girls who have now nearly completed their full growth. This statement is based upon observations on several different races and in various conditions of life.

II. Children of American-born parents are, in this community, taller and heavier than children of foreign-born parents, a superiority which seems to depend partly on the greater average comfort in which such children live and grow up, and partly upon differences of race or stock.

III. Pupils of American parentage at the public Latin School, private Latin School, and Massachusetts Institute of Technology are (apparently for similar reasons) superior in height and weight to the generality of boys of American parentage attending the public schools.

IV. Pupils of the same selected schools are also taller and heavier than English boys of the non-laboring classes attending public schools and universities, the superiority in weight being, as a rule, more marked than that in height.

V. The relation of weight to height in growing children is such that at heights below 58 inches boys are heavier than girls in proportion to their stature. At heights above 58 inches the reverse is the case.

Conclusion.

Both the number and the value of the conclusions arrived at in this investigation are diminished by the lack of similar collections of statistics in other communities with which a

comparison may be made. This being the case the following brief enumeration of the points to which the attention of the collector of vital statistics may profitably be directed will, perhaps, not be considered out of place: —

I. *The influence of geographical and climatic conditions on the size of growing children.*— It has been shown by the researches of Dr. Gould and Dr. Baxter that the size of adult native Americans is very different in different States of the Union, and even in different parts of the same State. It would be interesting to determine by observations on children how early in life this difference becomes apparent.

II. *The number of generations necessary for the complete development of the influence of changed climatic conditions on the rate of growth of a given race.*— It has already been shown (see p. 299) that this influence apparently begins to be felt in the first generation, and it would be of interest to trace the accumulating effect through successive generations by means of inquiries as to the ancestry of the individuals measured. This could most readily be accomplished in those Western communities which consist almost exclusively of emigrants (and their decendants) from some limited region of the Old World.

III. *The effect (if any exists) of the season of the year on the rate of growth.*—This would be readily ascertained by successive spring and autumn observations on growing children; and it is in recording measurements of this sort that fathers of families and all others having charge of children have it in their power to contribute most efficiently to the solution of anthropometrical and ethnological questions.

IV. *The comparative effect of city and of country life on the rate of growth.*— In investigating this subject the effect of climatic influences must be eliminated by restricting the comparison to cities and the *adjacent* country, and regard must be paid to the race or stock and to the social condition of the individuals selected for comparison.

V. *The relation between diseases and the rate of growth.*— For example, it would be interesting to inquire whether, in the rapid growth which is said to follow certain diseases, especially fevers, the height and weight increase in their normal ratio; whether this accelerated growth *after* the disease is simply a compensation for a retardation *during* the disease; whether abnormally rapid growth causes a predisposition to disease, and whether any connection can be traced between the rate of growth and the frequency with which certain diseases of growing children (*e. g.*, chorea) occur at different ages.

VI. *The effect of local hygienic conditions on the physique of growing children.*— Since comfort and misery appear to have such a direct effect upon the size of growing children, it seems not improbable that a systematic comparative study of the physique of the growing population in different localities will throw light upon the relative sanitary conditions there prevalent.

It will thus be seen that a wide field is open for statistical research, in which nearly every one can do good work. The collection of physical data in regard to the human body has been in the past left almost exclusively in the hands of artists, who have sought to establish, as guides for their work, simple proportions between the various dimensions of the body, and of military statisticians, who have looked upon the human frame simply as a machine for performing a soldier's work, and have necessarily confined their observations to adult males. It is to be hoped that in the future the hygienist and the educator will recognize, in the physical measurements of growing children, a guide for the application of their sanitary regulations and a test for the efficiency of their systems of physical training.

APPENDIX.

By the kindness of President Runkle of the Massachusetts Institute of Technology the writer is enabled to present formulas which express the relation between the weight and height of growing children, from five to eighteen years of age, with considerable accuracy.*

The figures of Tables Nos. 23 and 24, showing the weights corresponding to each inch of height in the whole number of observations were placed by President Runkle in the hands of Professor Gaetano Lanza, who kindly subjected them to a mathematical discussion, and reported on the subject substantially as follows: —

The results of Dr. Bowditch's observations on the relation between the weight and height of boys from 42 to 66 inches, inclusive, are very fairly represented by the following empirical equation: —

Let $y =$ weight in lbs., and $x =$ height in inches; then

$$\log. y = 0.02007x + 0.77724, \text{ or } y = 10^{0.02007x + 0.77724}. \qquad \text{(A)}$$

The results of the observations on the relation between the weight and height of girls from 42 to 61 inches, inclusive, are represented with tolerable accuracy by the following empirical equation: —

Let $y =$ weight in lbs., and $x =$ height in inches; then

$$\log. y = 0.02164x + 0.69017, \text{ or } y = 10^{0.02164x + 0.69017}. \qquad \text{(B)}$$

The greatest difference between calculated and observed values is, in the case of boys, 0.65 lb., and in that of girls, 1.41 lbs., with one exception, where it is 3.01 lbs.

The equations

$$y = 0.002428x^{2.59} \qquad (A^1)$$

for the boys, and

$$y = 0.001277x^{2.75} \qquad (B^1)$$

for the girls, represent quite roughly the results.

The following table, embodying the results of Professor Lanza's discussion, shows at a glance the superior accuracy of the logarithmic equations (A) and (B), as compared with the exponential equations (A^1) and (B^1).

* For older as well as for younger children the formulas are obviously much less accurate.

TABLE No. 26.

Showing the agreement between the observed weights corresponding to each inch of height, and those calculated by the equations A, A^1, B, and B^1.

Height, in inches.	Boys — Weight in Pounds.					Girls — Weight in Pounds.				
	Observed.	Calculated.				Observed.	Calculated.			
		By (A).	Correction.	By (A^1).	Correction.		By (B).	Correction.	By (B^1).	Correction.
42,	41.77	41.71	+0.06	38.84	+2.93	40.89	39.72	+1.17	37.16	+3.73
43,	43.60	43.68	—0.08	41.28	+2.32	42.62	41.75	+0.87	39.65	+2.97
44,	45.63	45.74	—0.11	43.82	+1.81	44.53	43.89	+0.64	42.23	+2.30
45,	47.58	47.91	—0.36	46.44	+1.11	46.45	46.13	+0.32	44.92	+1.53
46,	49.65	50.17	—0.52	49.16	+0.49	48.51	48.49	+0.02	47.72	+0.79
47,	52.07	52.55	—0.48	51.98	+0.09	50.71	50.96	—0.25	50.63	+0.08
48,	54.57	55.03	—0.46	54.89	—0.32	53.19	53.57	—0.38	53.65	—0.46
49,	57.31	57.63	—0.32	57.90	—0.59	56.06	56.30	—0.24	56.78	—0.71
50,	60.20	60.35	—0.15	61.01	—0.81	58.75	59.18	—0.43	60.02	—1.27
51,	63.23	63.21	+0.02	64.22	—0.99	61.39	62.20	—0.81	63.38	—1.99
52,	66.27	66.20	+0.07	67.53	—1.26	64.36	65.38	—1.02	66.86	—2.50
53,	69.20	69.34	—0.14	70.95	—1.75	67.54	68.72	—1.18	70.46	—2.92
54,	72.73	72.61	+0.12	74.47	—1.74	71.01	72.23	—1.22	74.17	—3.16
55,	76.44	76.05	+0.39	78.09	—1.65	74.90	75.92	—1.02	78.01	—3.11
56,	80.24	79.65	+0.59	81.83	—1.59	78.82	79.80	—0.98	81.97	—3.15
57,	84.04	83.41	+0.63	85.66	—1.22	83.38	83.88	—0.50	86.06	—2.68
58,	87.86	87.36	+0.50	89.61	—1.75	87.92	88.16	—0.24	90.28	—2.56
59,	91.58	91.48	+0.10	93.67	—2.09	93.29	92.67	+0.62	94.62	—1.33
60,	95.51	95.82	—0.31	97.83	—2.32	98.81	97.40	+1.41	99.10	—0.29
61,	100.54	100.35	+0.19	102.11	—1.57	105.39	102.38	+3.01	103.70	+1.69
62,	105.63	105.09	+0.54	106.50	—0.87	.....	.....	.....	.....	.....
63,	110.71	110.06	+0.65	111.01	—0.30	.....	.....	.....	.....	.....
64,	115.86	115.27	+0.59	115.63	+0.23	.....	.....	.....	.....	.....
65,	121.01	120.72	+0.29	120.37	+0.64	.....	.....	.....	.....	.....
66,	126.61	126.43	+0.18	125.23	+1.38	.....	.....	.....	.....	.....

TABLE No. 1.— *Showing Average Heights and Weights of Boston School Boys.*

AVERAGE HEIGHTS (without shoes).

AGE AT LAST BIRTHDAY.	PARENTAGE.								
	AMERICAN.			IRISH.			AMERICAN AND IRISH.		
	No. of Obs.	Inches.	Centimeters.	No. of Obs.	Inches.	Centimeters.	No. of Obs.	Inches.	Centimeters.
Five, . .	201	41.74	106.0	366	41.59	105.5	42	42.16	107.1
Six, . .	342	44.10	112.0	503	43.74	111.1	65	43.56	110.7
Seven, . .	369	46.21	117.4	562	45.61	115.8	77	45.68	116.1
Eight, . .	407	48.16	122.3	588	47.72	121.2	66	47.53	120.7
Nine, . .	381	50.09	127.2	556	49.53	125.2	67	49.30	125.2
Ten, . .	360	52.21	132.6	571	51.57	131.1	56	51.35	130.4
Eleven, . .	350	54.01	137.2	548	53.10	134.9	55	53.33	135.4
Twelve, . .	373	55.78	141.7	497	54.82	139.3	53	55.13	140.0
Thirteen, .	391	58.17	147.7	463	56.70	144.0	45	56.69	143.9
Fourteen, .	386	61.08	155.1	334	58.88	149.5	22	59.28	150.5
Fifteen, . .	342	62.96	159.9	155	61.15	155.3	16	} 61.93	157.3
Sixteen, . .	232	65.58	166.5	61	64.09	162.8	6		
Seventeen, .	128	66.29	168.4	26	} 66.20	168.2			
Eighteen, .	65	66.76	169.5	5					
Totals, .	4,327			5,235			570		

TABLE No. 1 (Continued).— *Showing Average Heights and Weights of Boston School Boys.*

AVERAGE HEIGHTS (without shoes).

AGE AT LAST BIRTHDAY.	PARENTAGE.								
	GERMAN.			ONE OR BOTH ENGLISH.			TOTALS.		
	No. of Obs.	Inches.	Centimeters.	No. of Obs.	Inches.	Centimeters.	No. of Obs.	Inches.	Centimeters.
Five, . .	48	41.08	104.3	75	41.40	105.2	848	41.57	105.6
Six, . . .	71	43.50	110.5	99	43.64	110.9	1,258	43.75	111.1
Seven, . .	87	45.25	114.1	113	45.60	115.8	1,419	45.74	116.2
Eight, . .	84	47.13	119.7	136	47.50	120.7	1,481	47.76	121.3
Nine, . .	87	48.85	124.1	130	49.39	125.4	1,437	49.69	126.2
Ten, . .	75	51.21	130.1	105	51.62	131.2	1,363	51.68	131.3
Eleven, . .	91	52.92	134.4	93	52.81	134.1	1,298	53.33	135.4
Twelve, . .	76	54.55	138.6	101	54.89	139.4	1,253	55.11	140.0
Thirteen, .	53	56.70	144.0	84	56.76	144.2	1,160	57.21	145.3
Fourteen, .	38	59 14	151.2	47	59.40	150.9	908	59.88	152.1
Fifteen, . .	26	62.06	157.6	51	61.48	156.2	636	62.30	158.2
Sixteen, . .	7			27	63.88	162.2	359	65.00	165.1
Seventeen, .	7	64.75	164.4				192	66.16	168.0
Eighteen, .	2						84	66.66	169.3
Totals, .	752			1,061			13,691		

TABLE No. 1 (Continued).— *Showing Average Heights and Weights of Boston School Boys.*

AVERAGE WEIGHTS (in ordinary dress).

AGE AT LAST BIRTHDAY.	PARENTAGE.								
	AMERICAN.			IRISH.			AMERICAN AND IRISH.		
	No. of Obs.	Pounds.	Kilograms.	No. of Obs.	Pounds.	Kilograms.	No. of Obs.	Pounds.	Kilograms.
Five,	201	41.20	18.71	366	41.33	18.75	42	41.99	19.05
Six,	342	45.14	20.48	503	45.25	20.52	65	44.73	20.29
Seven,	369	49.47	22.44	562	48.90	22.19	77	49.08	22.26
Eight,	407	54.43	24.70	588	54.12	24.55	66	52.86	23.97
Nine,	381	59.97	26.58	556	58.92	26.73	67	57.27	25.97
Ten,	360	66.62	30.22	571	64.99	29.48	56	64.57	29.29
Eleven,	350	72.39	32.83	548	69.60	31.56	55	70.34	31.91
Twelve,	373	79.82	36.21	497	75.70	34.34	53	75.66	34.32
Thirteen,	391	88.26	40.04	463	82.84	37.58	45	81.42	36.93
Fourteen,	386	99.28	45.03	334	91.19	41.36	22	91.89	41.68
Fifteen,	342	110.84	50.26	155	101.21	45.90	16	} 107.91	48.96
Sixteen,	232	123.67	56.09	61	112.88	51.19	6		
Seventeen,	128	128.72	58.40	26	} 127.40	57.80			
Eighteen,	65	132.71	60.20	5					
Totals,	4,327			5,235			570		

TABLE No. 1 (Concluded).— *Showing Average Heights and Weights of Boston School Boys.*

AVERAGE WEIGHTS (in ordinary dress).

AGE AT LAST BIRTHDAY.	PARENTAGE.								
	GERMAN.			ONE OR BOTH ENGLISH.			TOTALS.		
	No. of Obs.	Pounds.	Kilograms.	No. of Obs.	Pounds.	Kilograms.	No. of Obs.	Pounds.	Kilograms.
Five, . .	48	40.57	18.39	75	40.07	18.18	848	41.09	18.64
Six, . .	71	44.09	20.01	99	45.03	20.43	1,258	45.17	20.49
Seven, . .	87	49.12	22.29	113	48.20	21.86	1,419	49.07	22.26
Eight, . .	84	52.94	24.02	136	53.21	24.14	1,481	53.92	24.46
Nine, . .	87	58.25	26.43	130	58.57	26.58	1,437	59.23	26.87
Ten, . .	75	63.93	29.00	105	65.06	29.51	1,363	65.30	29.62
Eleven, . .	91	69.09	31.34	93	67.11	30.44	1,293	70.18	31.84
Twelve, . .	76	75.70	34.34	101	75.39	34.20	1,253	76.92	34.89
Thirteen, .	53	83.85	38.04	84	84.72	38.44	1,160	84.84	38.49
Fourteen. .	38	92.87	42.12	47	92.72	42.07	908	94.91	42.95
Fifteen, . .	26	107.53	48.80	51	101.21	45.90	636	107.10	48.59
Sixteen, . .	7			27	120.32	54.57	359	121.01	54.90
Seventeen, .	7	123.67	56.09				192	127.49	57.84
Eighteen, .	2						84	132.55	60.13
Totals, .	752			1,061			13,691		

TABLE NO. 2.— *Showing Average Heights and Weights of Boston School Girls.*

AVERAGE HEIGHTS (without shoes).

AGE AT LAST BIRTHDAY.	PARENTAGE.								
	AMERICAN.			IRISH.			AMERICAN AND IRISH.		
	No. of Obs.	Inches.	Centimeters.	No. of Obs.	Inches.	Centimeters.	No. of Obs.	Inches.	Centimeters.
Five,	127	41.47	105.3	236	41.18	104.6	29	41.42	105.2
Six,	236	43.66	110.9	395	43.29	109.9	43	43.18	109.6
Seven,	346	45.94	116.7	426	45.45	115.4	53	45.69	116.0
Eight,	338	48.07	122.1	486	47.39	120.4	59	47.40	120.4
Nine,	323	49.61	126.0	416	49.27	125.2	48	48.77	123.9
Ten,	336	51.78	131.5	379	51.20	130.1	51	51.17	129.9
Eleven,	290	53.79	136.6	340	53.13	134.9	36	53.51	135.9
Twelve,	309	57.16	145.2	307	55.41	140.8	28	54.91	139.5
Thirteen,	307	58.75	149.2	278	57.64	146.3	28	57.81	146.8
Fourteen,	290	60.32	153.2	192	59.67	151.5	23	59.44	151.0
Fifteen,	255	61.39	155.9	95	60.47	153.5	11	} 61.07	155.0
Sixteen,	238	61.72	156.7	49	61.05	155.1	9		
Seventeen,	168	61.99	157.4	18	} 62.00	157.5			
Eighteen,	118	62.01	157.5	6					
Totals,	3,681			3,623			418		

TABLE No. 26.

Showing the agreement between the observed weights corresponding to each inch of height, and those calculated by the equations A, A^1, B, and B^1.

Height, in inches.	Boys — Weight in Pounds.					Girls — Weight in Pounds.				
	Observed.	Calculated.				Observed.	Calculated.			
		By (A).	Correction.	By (A^1).	Correction.		By (B).	Correction.	By (B^1).	Correction.
42,	41.77	41.71	+0.06	38.84	+2.93	40.89	39.72	+1.17	37.16	+3.73
43,	43.60	43.68	—0.08	41.28	+2.32	42.62	41.75	+0.87	39.65	+2.97
44,	45.63	45.74	—0.11	43.82	+1.81	44.53	43.89	+0.64	42.23	+2.30
45,	47.58	47.91	—0.36	46.44	+1.11	46.45	46.13	+0.32	44.92	+1.53
46,	49.65	50.17	—0.52	49.16	+0.49	48.51	48.49	+0.02	47.72	+0.79
47,	52.07	52.55	—0.48	51.98	+0.09	50.71	50.96	—0.25	50.63	+0.08
48,	54.57	55.03	—0.46	54.89	—0.32	53.19	53.57	—0.38	53.65	—0.46
49,	57.31	57.63	—0.32	57.90	—0.59	56.06	56.30	—0.24	56.78	—0.71
50,	60.20	60.35	—0.15	61.01	—0.81	58.75	59.18	—0.43	60.02	—1.27
51,	63.23	63.21	+0.02	64.22	—0.99	61.39	62.20	—0.81	63.38	—1.99
52,	66.27	66.20	+0.07	67.53	—1.26	64.36	65.38	—1.02	66.86	—2.50
53,	69.20	69.34	—0.14	70.95	—1.75	67.54	68.72	—1.18	70.46	—2.92
54,	72.73	72.61	+0.12	74.47	—1.74	71.01	72.23	—1.22	74.17	—3.16
55,	76.44	76.05	+0.39	78.09	—1.65	74.90	75.92	—1.02	78.01	—3.11
56,	80.24	79.65	+0.59	81.83	—1.59	78.82	79.80	—0.98	81.97	—3.15
57,	84.04	83.41	+0.63	85.66	—1.22	83.38	83.88	—0.50	86.06	—2.68
58,	87.86	87.36	+0.50	89.61	—1.75	87.92	88.16	—0.24	90.28	—2.56
59,	91.58	91.48	+0.10	93.67	—2.09	93.29	92.67	+0.62	94.62	—1.33
60,	95.51	95.82	—0.31	97.83	—2.32	98.81	97.40	+1.41	99.10	—0.29
61,	100.54	100.35	+0.19	102.11	—1.57	105.39	102.38	+3.01	103.70	+1.69
62,	105.63	105.09	+0.54	106.50	—0.87	.....	.....	.....	.....	.....
63,	110.71	110.06	+0.65	111.01	—0.30	.....	.....	.....	.....	.....
64,	115.86	115.27	+0.59	115.63	+0.23	.....	.....	.....	.....	.....
65,	121.01	120.72	+0.29	120.37	+0.64	.....	.....	.....	.....	.....
66,	126.61	126.43	+0.18	125.23	+1.38	.....	.....	.....	.....	.....

TABLE No. 1.— *Showing Average Heights and Weights of Boston School Boys.*

AVERAGE HEIGHTS (without shoes).

AGE AT LAST BIRTHDAY.	PARENTAGE.								
	AMERICAN.			IRISH.			AMERICAN AND IRISH.		
	No. of Obs.	Inches.	Centimeters.	No. of Obs.	Inches.	Centimeters.	No. of Obs.	Inches.	Centimeters.
Five, . .	201	41.74	106.0	366	41.59	105.5	42	42.16	107.1
Six, . .	342	44.10	112.0	503	43.74	111.1	65	43.56	110.7
Seven, . .	369	46.21	117.4	562	45.61	115.8	77	45.68	116.1
Eight, . .	407	48.16	122.3	588	47.72	121.2	66	47.53	120.7
Nine, . .	381	50.09	127.2	556	49.53	125.2	67	49.30	125.2
Ten, . .	360	52.21	132.6	571	51.57	131.1	56	51.35	130.4
Eleven, . .	350	54.01	137.2	548	53.10	134.9	55	53.33	135.4
Twelve, . .	373	55.78	141.7	497	54.82	139.3	53	55.13	140.0
Thirteen, .	391	58.17	147.7	463	56.70	144.0	45	56.69	143.9
Fourteen, .	386	61.08	155.1	334	58.88	149.5	22	59.28	150.5
Fifteen, . .	342	62.96	159.9	155	61.15	155.3	16	} 61.93	157.3
Sixteen, . .	232	65.58	166.5	61	64.09	162.8	6		
Seventeen, .	128	66.29	168.4	26	} 66.20	168.2			
Eighteen, .	65	66.76	169.5	5					
Totals, .	4,327			5,235			570		

TABLE No. 1 (Continued).— *Showing Average Heights and Weights of Boston School Boys.*

AVERAGE HEIGHTS (without shoes).

AGE AT LAST BIRTHDAY.	PARENTAGE.								
	GERMAN.			ONE OR BOTH ENGLISH.			TOTALS.		
	No. of Obs.	Inches.	Centimeters.	No. of Obs.	Inches.	Centimeters.	No. of Obs.	Inches.	Centimeters.
Five,	48	41.08	104.3	75	41.40	105.2	848	41.57	105.6
Six,	71	43.50	110.5	99	43.64	110.9	1,258	43.75	111.1
Seven,	87	45.25	114.1	113	45.60	115.8	1,419	45.74	116.2
Eight,	84	47.13	119.7	136	47.50	120.7	1,481	47.76	121.3
Nine,	87	48.85	124.1	130	49.39	125.4	1,437	49.69	126.2
Ten,	75	51.21	130.1	105	51.62	131.2	1,363	51.68	131.3
Eleven,	91	52.92	134.4	93	52.81	134.1	1,293	53.33	135.4
Twelve,	76	54.55	138.6	101	54.89	139.4	1,253	55.11	140.0
Thirteen,	53	56.70	144.0	84	56.76	144.2	1,160	57.21	145.3
Fourteen,	38	59 14	151.2	47	59.40	150.9	908	59.88	152.1
Fifteen,	26	62.06	157.6	51	61.48	156.2	636	62.30	158.2
Sixteen,	7			27	63.88	162.2	359	65.00	165.1
Seventeen,	7	64.75	164.4				192	66.16	168.0
Eighteen,	2						84	66.66	169.3
Totals,	752			1,061			13,691		

TABLE No. 1 (Continued).— *Showing Average Heights and Weights of Boston School Boys.*

AVERAGE WEIGHTS (in ordinary dress).

AGE AT LAST BIRTHDAY.	PARENTAGE.								
	AMERICAN.			IRISH.			AMERICAN AND IRISH.		
	No. of Obs.	Pounds.	Kilograms.	No. of Obs.	Pounds.	Kilograms.	No. of Obs.	Pounds.	Kilograms.
Five,	201	41.20	18.71	366	41.33	18.75	42	41.99	19.05
Six,	342	45.14	20.48	503	45.25	20.52	65	44.73	20.29
Seven,	369	49.47	22.44	562	48.90	22.19	77	49.08	22.26
Eight,	407	54.43	24.70	588	54.12	24.55	66	52.86	23.97
Nine,	381	59.97	26.58	556	58.92	26.73	67	57.27	25.97
Ten,	360	66.62	30.22	571	64.99	29.48	56	64.57	29.29
Eleven,	350	72.39	32.83	548	69.60	31.56	55	70.34	31.91
Twelve,	373	79.82	36.21	497	75.70	34.34	53	75.66	34.32
Thirteen,	391	88.26	40.04	463	82.84	37.58	45	81.42	36.93
Fourteen,	386	99.28	45.03	334	91.19	41.36	22	91.89	41.68
Fifteen,	342	110.84	50.26	155	101.21	45.90	16	} 107.91	48.96
Sixteen,	232	123.67	56.09	61	112.88	51.19	6		
Seventeen,	128	128.72	58.40	26	} 127.40	57.80			
Eighteen,	65	132.71	60.20	5					
Totals,	4,327			5,235			570		

TABLE No. 1 (Concluded).— *Showing Average Heights and Weights of Boston School Boys.*

AVERAGE WEIGHTS (in ordinary dress).

AGE AT LAST BIRTHDAY.	PARENTAGE.								
	GERMAN.			ONE OR BOTH ENGLISH.			TOTALS.		
	No. of Obs.	Pounds.	Kilograms.	No. of Obs.	Pounds.	Kilograms.	No. of Obs.	Pounds.	Kilograms.
Five, . .	48	40.57	18.39	75	40.07	18.18	848	41.09	18.64
Six, . .	71	44.09	20.01	99	45.03	20.43	1,258	45.17	20.49
Seven, . .	87	49.12	22.29	113	48.20	21.86	1,419	49.07	22.26
Eight, . .	84	52.94	24.02	136	53.21	24.14	1,481	53.92	24.46
Nine, . .	87	58.25	26.43	130	58.57	26.58	1,437	59.23	26.87
Ten, . .	75	63.93	29.00	105	65.06	29.51	1,368	65.30	29.62
Eleven, . .	91	69.09	31.34	93	67.11	30.44	1,293	70.18	31.84
Twelve, . .	76	75.70	34.34	101	75.39	34.20	1,253	76.92	34.89
Thirteen, .	53	83.85	38.04	84	84.72	38.44	1,160	84.84	38.49
Fourteen. .	38	92.87	42.12	47	92.72	42.07	908	94.91	42.95
Fifteen, . .	26	107.53	48.80	51	101.21	45.90	636	107.10	48.59
Sixteen, . .	7			27	120.32	54.57	359	121.01	54.90
Seventeen, .	7	123.67	56.09				192	127.49	57.84
Eighteen, .	2						84	132.55	60.13
Totals, .	752			1,061			13,691		

TABLE NO. 2.— *Showing Average Heights and Weights of Boston School Girls.*

AVERAGE HEIGHTS (without shoes).

AGE AT LAST BIRTHDAY.	PARENTAGE.								
	AMERICAN.			IRISH.			AMERICAN AND IRISH.		
	No. of Obs.	Inches.	Centimeters.	No. of Obs.	Inches.	Centimeters.	No. of Obs.	Inches.	Centimeters.
Five,	127	41.47	105.3	236	41.18	104.6	29	41.42	105.2
Six,	236	43.66	110.9	395	43.29	109.9	43	43.18	109.6
Seven,	346	45.94	116.7	426	45.45	115.4	53	45.69	116.0
Eight,	338	48.07	122.1	486	47.39	120.4	59	47.40	120.4
Nine,	323	49.61	126.0	416	49.27	125.2	48	48.77	123.9
Ten,	336	51.78	131.5	379	51.20	130.1	51	51.17	129.9
Eleven,	290	53.79	136.6	340	53.13	134.9	36	53.51	135.9
Twelve,	309	57.16	145.2	307	55.41	140.8	28	54.91	139.5
Thirteen,	307	58.75	149.2	278	57.64	146.3	28	57.81	146.8
Fourteen,	290	60.32	153.2	192	59.67	151.5	23	59.44	151.0
Fifteen,	255	61.39	155.9	95	60.47	153.5	11	} 61.07	155.0
Sixteen,	238	61.72	156.7	49	61.05	155.1	9		
Seventeen,	168	61.99	157.4	18	} 62.00	157.5			
Eighteen,	118	62.01	157.5	6					
Totals,	3,681			3,623			418		

TABLE No. 2 (Continued).— *Showing Average Heights and Weights of Boston School Girls.*

AVERAGE HEIGHTS (without shoes).

AGE AT LAST BIRTHDAY.	PARENTAGE.								
	GERMAN.			ONE OR BOTH ENGLISH.			TOTALS.		
	No. of Obs.	Inches.	Centimeters.	No. of Obs.	Inches.	Centimeters.	No. of Obs.	Inches.	Centimeters.
Five,	50	41.40	105.1	75	41.14	104.5	605	41.29	104.9
Six,	66	43.09	109.4	98	43.32	110.0	987	43.35	110.1
Seven,	82	44.91	114.0	104	44.81	113.8	1,199	45.52	115.6
Eight,	75	47.15	119.7	117	47.63	121.0	1,299	47.58	120.9
Nine,	76	49.20	125.0	96	49.37	125.4	1,149	49.37	125.4
Ten,	57	50.76	128.9	112	50.98	129.5	1,089	51.34	130.4
Eleven,	57	52.62	133.9	88	53.63	136.2	936	53.42	135.7
Twelve,	53	54.73	139.0	89	55.89	141.9	935	55.88	141.9
Thirteen,	31	57.82	146.8	69	57.71	146.6	830	58.16	147.7
Fourteen,	23	58.55	148.7	56	60.15	152.8	675	59.94	152.3
Fifteen,	10			48	60.93	154.7	459	61.10	155.2
Sixteen,	4	59.81	151.9	27	62.17	157.9	353	61.59	156.4
Seventeen,	1						233	61.92	157.2
Eighteen,							155	61.95	157.3
Totals,	585			979			10,904		

TABLE No. 2 (Continued).— *Showing Average Heights and Weights of Boston School Girls.*

AVERAGE WEIGHTS (in ordinary dress).

AGE AT LAST BIRTHDAY.	PARENTAGE.								
	AMERICAN.			IRISH.			AMERICAN AND IRISH.		
	No. of Obs.	Pounds.	Kilograms.	No. of Obs.	Pounds.	Kilograms.	No. of Obs.	Pounds.	Kilograms.
Five,	127	39.82	18.06	236	39.63	17.97	29	40.59	18.42
Six,	236	43.81	19.87	395	43.21	19.60	43	43.02	19.52
Seven,	346	48.02	21.78	426	47.64	21.61	53	47.28	21.44
Eight,	338	52.93	24.01	486	51.80	23.50	59	51.17	23.21
Nine,	323	57.52	26.10	416	56.76	25.75	48	54.66	24.79
Ten,	336	64.09	29.07	379	61.59	27.94	51	61.17	27.69
Eleven,	290	70.26	31.87	340	67.83	30.77	36	68.02	30.85
Twelve,	309	81.35	36.90	307	76.15	34.55	28	74.55	33.82
Thirteen,	307	91.18	41.36	278	85.76	38.91	28	85.89	38.97
Fourteen,	290	100.32	45.50	192	96.36	43.71	23	97.83	44.37
Fifteen,	255	108.42	49.17	95	100.46	45.56	11	109.51	49.68
Sixteen,	238	112.97	51.24	49	108.56	49.24	9		
Seventeen,	168	115.84	52.54	18	115.82	52.49			
Eighteen,	118	115.80	52.52	6					
Totals,	3,681			3,623			418		

Plate III. *Showing rate of growth of Boston school children of Irish parentage.*

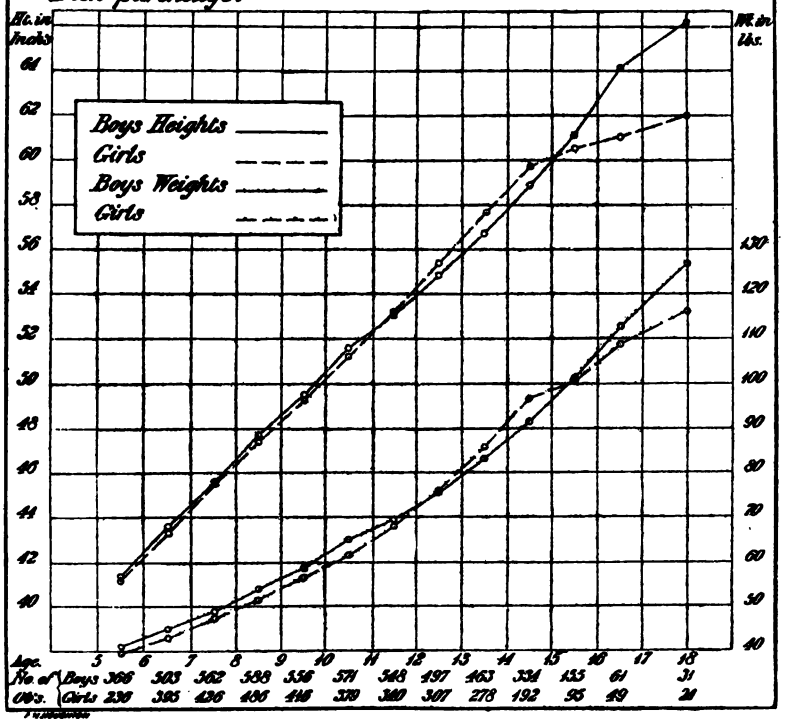


Plate IV. *Showing rate of growth of Belgian children according to Quetelet's observations.*

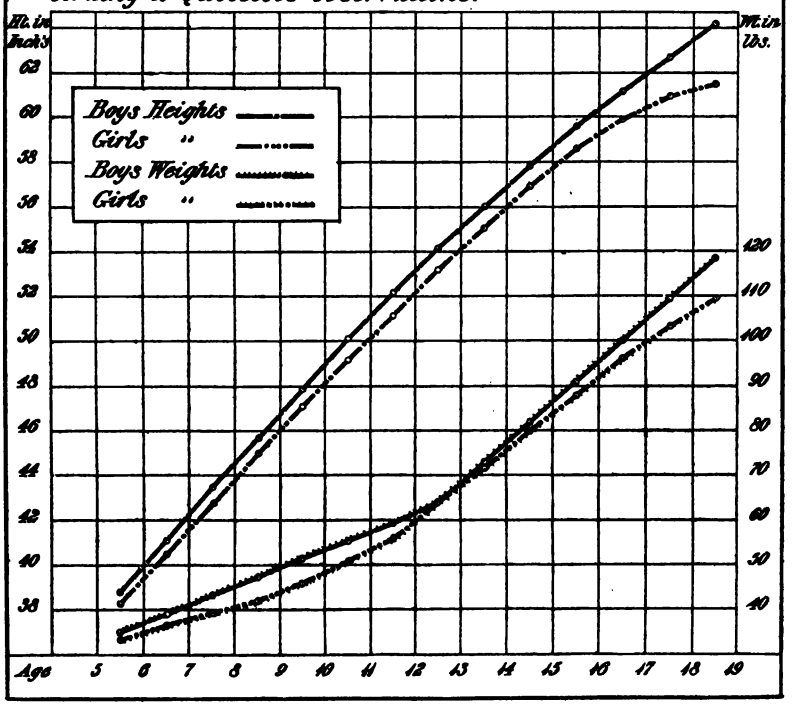


Plate V. *Showing rate of growth of English children employed in factories of Manchester and Stockport. – Cowell.*

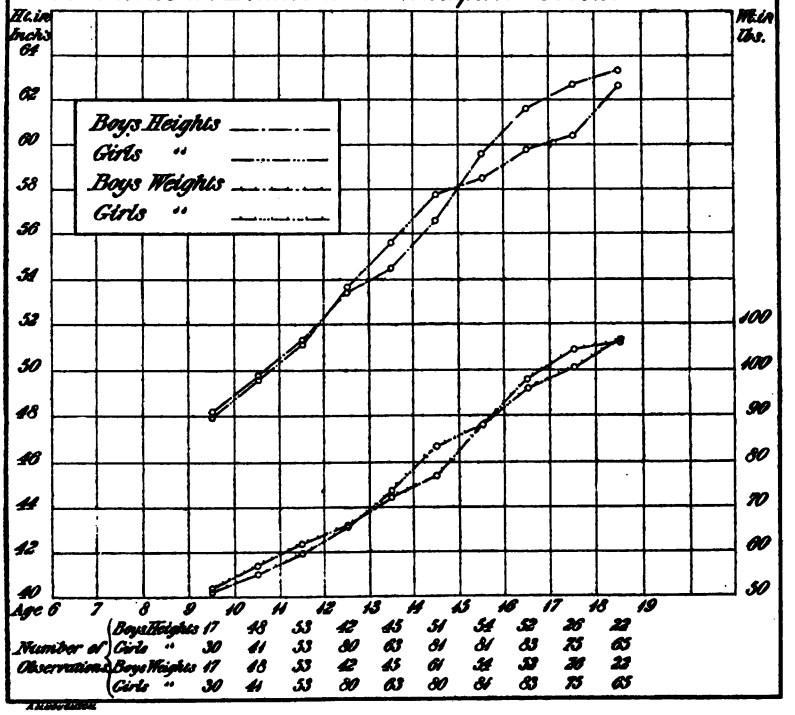


Plate VI. *Showing rate of growth of Boston school boys.*

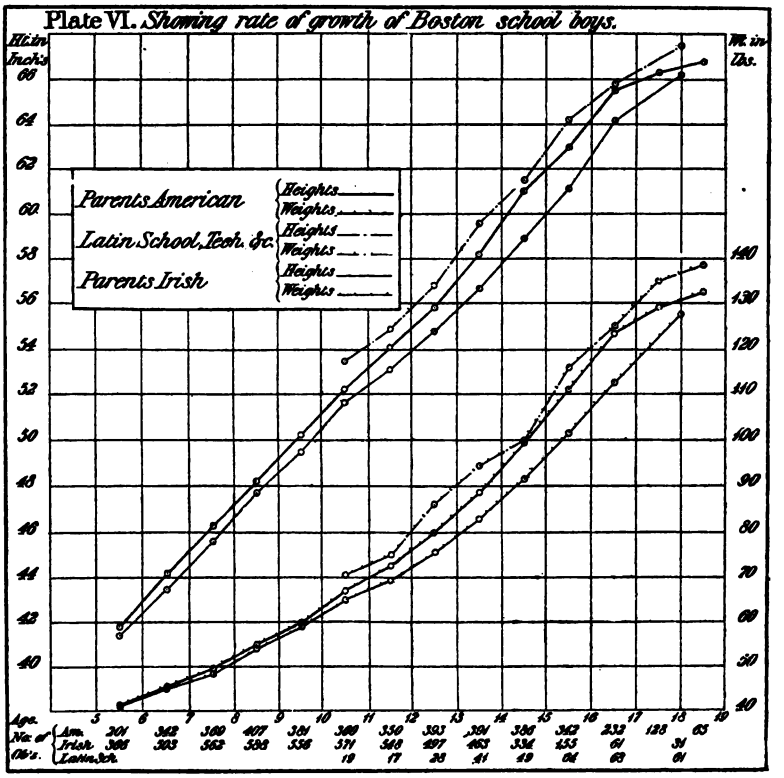


TABLE No. 2 (Concluded).— *Showing Average Heights and Weights of Boston School Girls.*

AVERAGE WEIGHTS (in ordinary dress).

AGE AT LAST BIRTHDAY.	PARENTAGE.								
	GERMAN.			ONE OR BOTH ENGLISH.			TOTALS.		
	No. of Obs.	Pounds.	Kilograms.	No. of Obs.	Pounds.	Kilograms.	No. of Obs.	Pounds.	Kilograms.
Five, . .	50	39.73	18.02	75	39.05	17.72	605	39.66	17.99
Six, . .	66	42.68	19.36	98	43.26	19.62	987	43.28	19.63
Seven, . .	82	46.26	20.98	104	46.26	20.99	1,199	47.46	27.10
Eight, . .	75	50.60	22.96	117	52.45	23.79	1,299	52.04	23.44
Nine, . .	76	57.37	26.02	96	55.96	25.40	1,149	57.07	25.91
Ten, . .	57	59.83	27.14	112	60.98	27.66	1,089	62.35	28.29
Eleven, . .	57	67.56	30.65	88	69.78	31.65	936	68.84	31.23
Twelve, . .	53	76.06	34.50	89	77.24	35.03	935	78.31	35.53
Thirteen, .	31	85.82	38.93	69	86.38	39.20	830	88.65	40.21
Fourteen, .	23	88.91	40.33	56	98.73	44.78	675	98.43	44.65
Fifteen, . .	10			48	105.53	47.88	459	106.08	48.12
Sixteen, . .	4	101.16	45.87	27	111.94	50.76	353	112.03	50.81
Seventeen, .	1						233	115.53	52.41
Eighteen, .							155	115.16	52.24
Totals, .	585			979			10,904		

TABLE NO. 3.— *Showing Annual Growth and Ratio of Weight to Height of Boston School Children.*

BOYS.

AGE.*	PARENTAGE.								
	AMERICAN.			IRISH.			AMERICAN AND IRISH.		
	Annual Increase.		Pounds per inch.	Annual Increase.		Pounds per inch.	Annual Increase.		Pounds per inch.
	Height, inches.	Weight, pounds.		Height, inches.	Weight, pounds.		Height, inches.	Weight, pounds.	
Five, . .			.987			.993			.996
Six, . .	2.36	3.94	1.023	2.15	3.92	1.034	1.40	2.74	1.027
Seven, . .	2.11	4.33	1.070	1.87	3.65	1.072	2.12	4.35	1.074
Eight, . .	1.95	4.96	1.130	2.11	5.22	1.134	1.85	3.78	1.112
Nine, . .	1.93	5.54	1.197	1.81	4.80	1.189	1.77	4.41	1.161
Ten, . .	2.12	6.65	1.276	2.04	6.07	1.260	2.05	7.30	1.257
Eleven, . .	1.80	5.77	1.340	1.53	4.61	1.310	1.98	5.77	1.319
Twelve, . .	1.77	7.43	1.431	1.72	6.10	1.381	1.80	5.32	1.372
Thirteen, .	2.39	8.44	1.517	1.88	7.14	1.461	1.56	5.76	1.436
Fourteen, .	2.91	11.02	1.625	2.18	8.35	1.548	2.59	10.47	1.550
Fifteen, . .	1.88	11.56	1.760	2.27	10.02	1.655			} 1.742
Sixteen, . .	2.62	12.83	1.885	2.94	11.67	1.761			
Seventeen, .	.71	5.05	1.941			} 1.924			
Eighteen, .	.47	3.99	1.988						

* See foot-note, p. 71.

TABLE No. 3 (Continued).— *Showing Annual Growth and Ratio of Weight to Height of Boston School Children.*

BOYS.

AGE.*	PARENTAGE.								
	GERMAN.			ONE OR BOTH ENGLISH.			TOTALS.		
	Annual Increase.		Pounds per inch.	Annual Increase.		Pounds per inch.	Annual Increase.		Pounds per inch.
	Height, inches.	Weight, pounds.		Height, inches.	Weight, pounds.		Height, inches.	Weight, pounds.	
Five, . .			.987			.967			.988
Six, . . .	2.42	3.52	1.013	2.24	4.96	1.031	2.18	4.08	1.032
Seven, . .	1.75	5.03	1.085	1.96	3.17	1.057	1.99	3.90	1.072
Eight, . .	1.88	3.82	1.123	1.90	5.01	1.119	2.02	4.85	1.129
Nine, . .	1.72	5.31	1.192	1.89	5.36	1.185	1.93	5.31	1.191
Ten, . .	2.36	5.68	1.248	2.23	6.49	1.260	1.99	6.07	1.263
Eleven, . .	1.71	5.16	1.305	1.19	2.05	1.270	1.65	4.88	1.315
Twelve, . .	1.63	6.61	1.388	2.08	8.28	1.373	1.78	6.74	1.395
Thirteen, .	2.15	8.15	1.477	1.87	9.33	1.492	2.10	7.92	1.482
Fourteen, .	2.44	9.02	1.570	2.64	8.00	1.561	2.67	10.07	1.585
Fifteen, . .	2.92	14.66	1.732	2.08	8.49	1.646	2.42	12.19	1.719
Sixteen, . .				2.40	19.11	1.883	2.70	13.91	1.861
Seventeen, .			1.952				1.16	6.48	1.927
Eighteen, .							.50	5.06	1.988

* See foot-note, p. 71.

TABLE No. 3 (Continued).— *Showing Annual Growth and Ratio of Weight to Height of Boston School Children.*

GIRLS.

AGE.*	PARENTAGE.								
	AMERICAN.			IRISH.			AMERICAN AND IRISH.		
	Annual Increase.		Pounds per inch.	Annual Increase.		Pounds per inch.	Annual Increase.		Pounds per inch.
	Height, inches.	Weight, pounds.		Height, inches.	Weight, pounds.		Height, inches.	Weight, pounds.	
Five,			.960			.962			.980
Six,	2.19	3.99	1.003	2.11	3.58	.998	1.76	2.43	.996
Seven,	2.28	4.21	1.045	2.16	4.43	1.048	2.51	4.26	1.034
Eight,	2.13	4.91	1.101	1.94	4.16	1.093	1.71	3.89	1.079
Nine,	1.54	4.59	1.159	1.88	4.96	1.152	1.37	3.49	1.120
Ten,	2.17	6.57	1.237	1.93	4.83	1.203	2.40	6.51	1.195
Eleven,	2.01	6.17	1.306	1.93	6.24	1.276	2.34	6.85	1.271
Twelve,	3.37	11.09	1.423	2.28	8.32	1.374	1.40	6.53	1.357
Thirteen,	1.59	9.83	1.552	2.23	9.61	1.487	2.90	11.34	1.486
Fourteen,	1.57	9.14	1.663	2.03	10.60	1.614	1.63	11.94	1.645
Fifteen,	1.07	8.10	1.766	.80	4.10	1.661			} 1.793
Sixteen,	.33	4.55	1.830	.58	8.10	1.778			
Seventeen,	.27	2.87	1.869			} 1.870			
Eighteen,	.02	—.04	1.867						

* See foot-note, p. 71.

TABLE No. 3 (Concluded).— *Showing Annual Growth and Ratio of Weight to Height of Boston School Children.*

GIRLS.

AGE.*	PARENTAGE.								
	GERMAN.			ONE OR BOTH ENGLISH.			TOTALS.		
	Annual Increase.		Pounds per inch.	Annual Increase.		Pounds per inch.	Annual Increase.		Pounds per inch.
	Height, inches.	Weight, pounds.		Height, inches.	Weight, pounds.		Height, inches.	Weight, pounds.	
Five,			.959			.947			.965
Six,	1.69	2.95	.990	2.18	4.21	.998	2.06	3.62	.998
Seven,	1.82	3.58	1.030	1.49	3.00	1.032	2.17	4.18	1.042
Eight,	2.24	4.34	1.073	2.82	6.19	1.101	2.06	4.58	1.093
Nine,	2.05	6.77	1.166	1.74	3.51	1.133	1.79	5.03	1.156
Ten,	1.56	2.46	1.178	1.61	5.02	1.197	1.97	5.28	1.214
Eleven,	1.86	7.73	1.284	2.65	8.80	1.301	2.08	6.49	1.288
Twelve,	2.11	8.50	1.393	2.26	7.46	1.382	2.46	9.47	1.401
Thirteen,	3.09	9.76	1.484	1.82	9.14	1.497	2.28	10.34	1.524
Fourteen,	.73	3.09	1.518	2.44	12.35	1.641	1.78	9.78	1.642
Fifteen,				.78	6.80	1.732	1.16	7.65	1.736
Sixteen,			1.691	1.24	6.41	1.800	.49	5.95	1.819
Seventeen,							.33	3.50	1.865
Eighteen,							.03	—.37	1.859

* See foot-note, p. 71.

Plate I. *Showing rate of growth of Boston school children Whole number of observations irrespective of nationality of parents.*

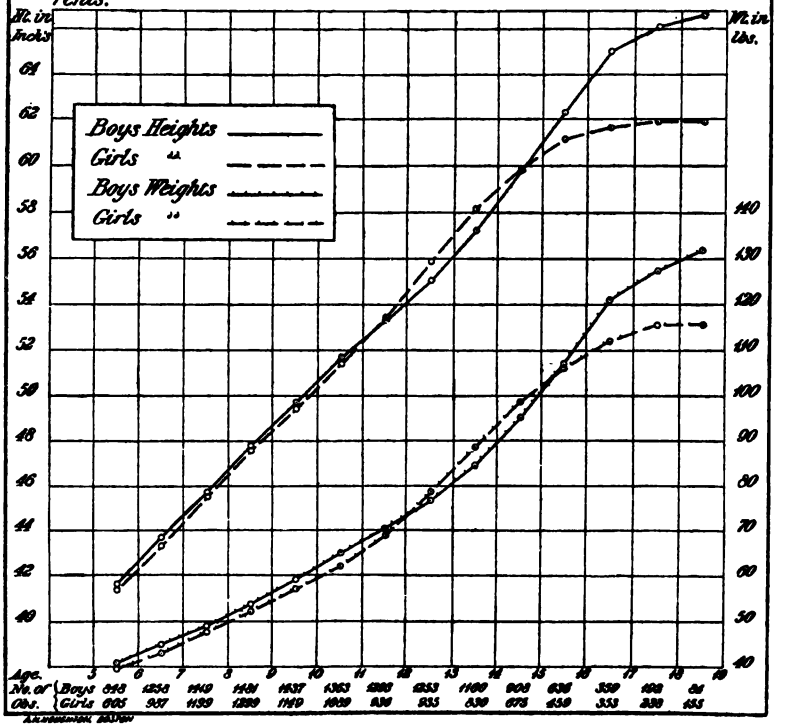


Plate II. *Showing rate of growth of Boston school children of American parentage.*

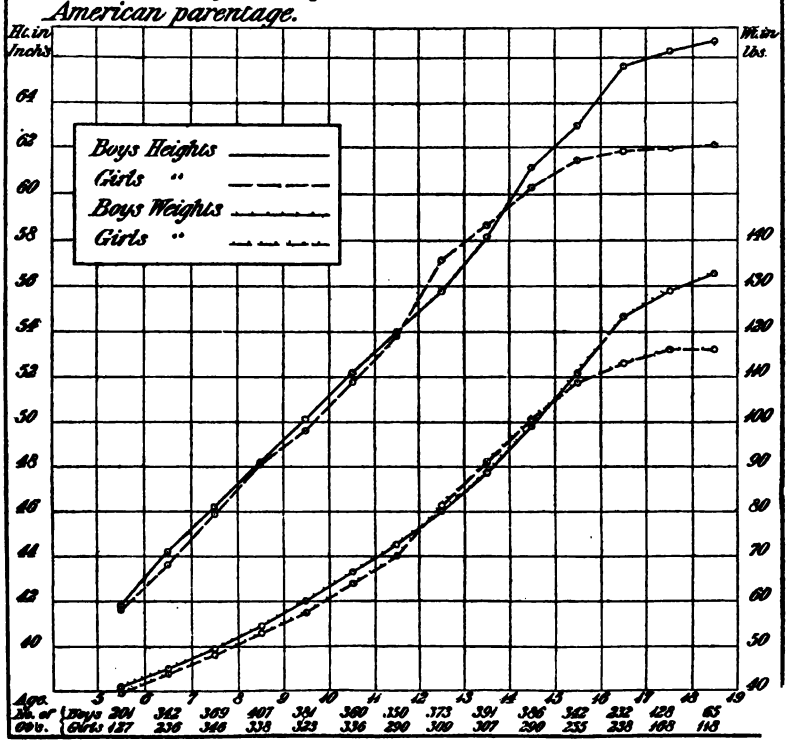


Plate III. *Showing rate of growth of Boston school children of Irish parentage.*

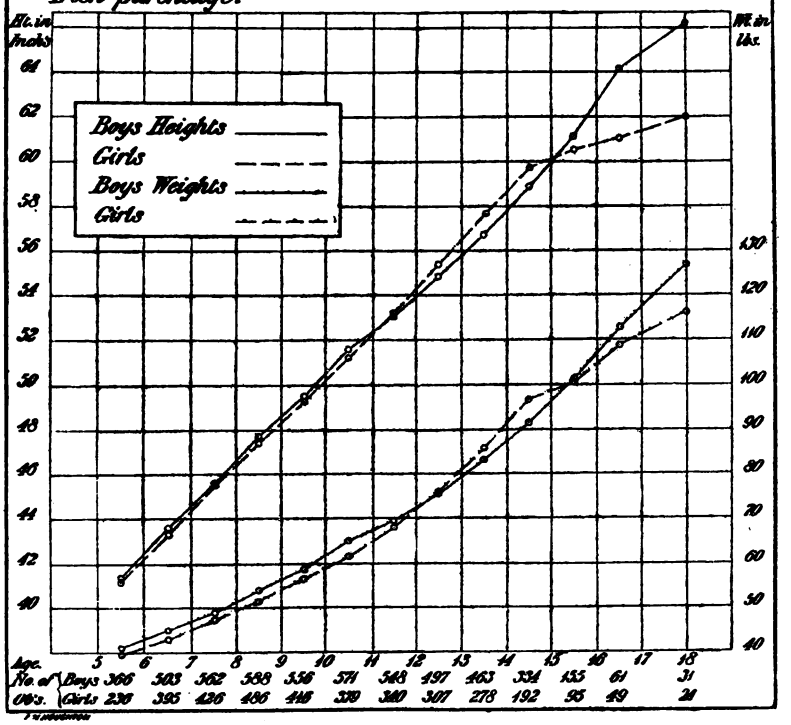


Plate IV. *Showing rate of growth of Belgian children according to Quetelet's observations.*

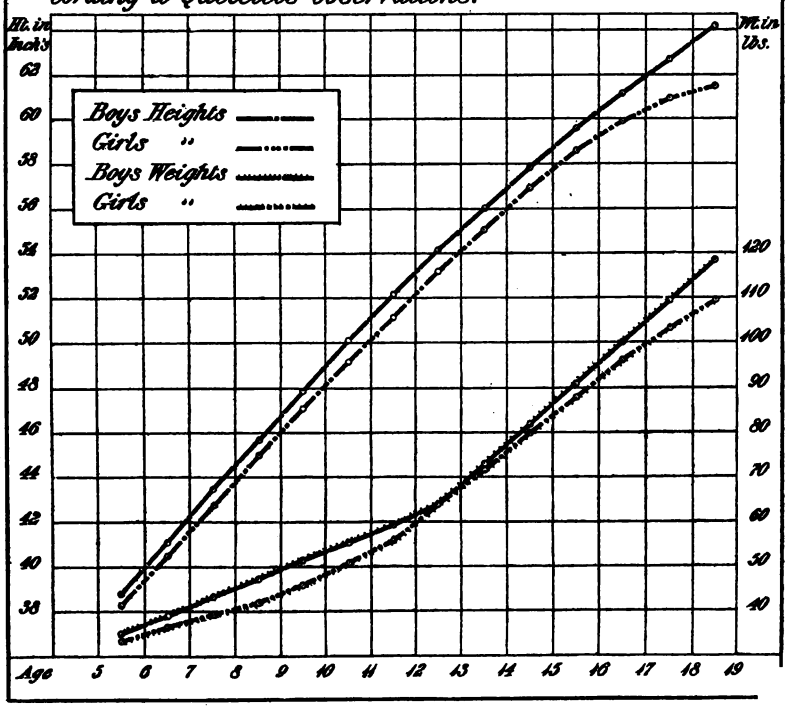


Plate V. *Showing rate of growth of English children employed in factories of Manchester and Stockport. – Cowell.*

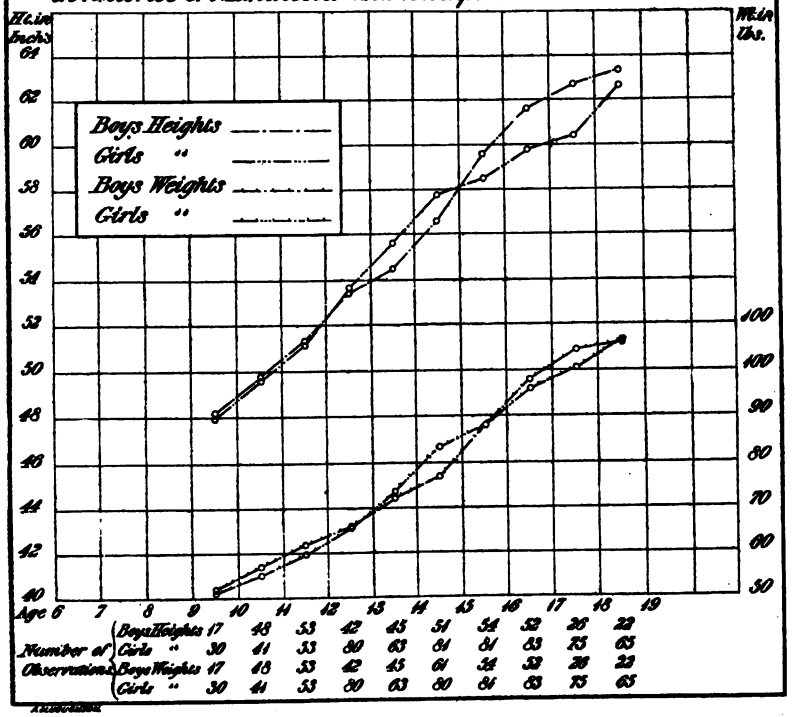


Plate VI. *Showing rate of growth of Boston school boys.*

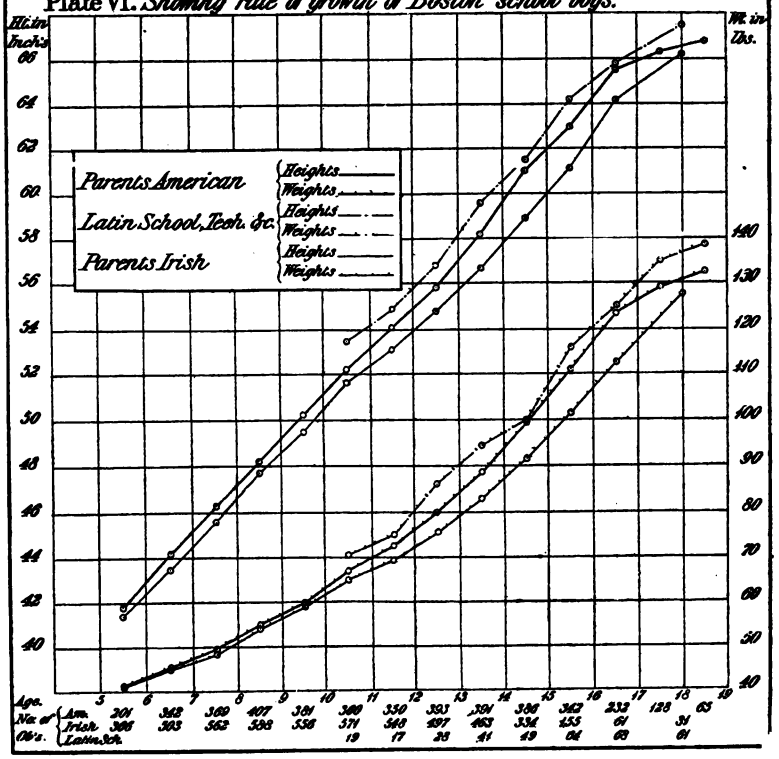


Plate VII. *Showing rate of growth of Boston school girls.*

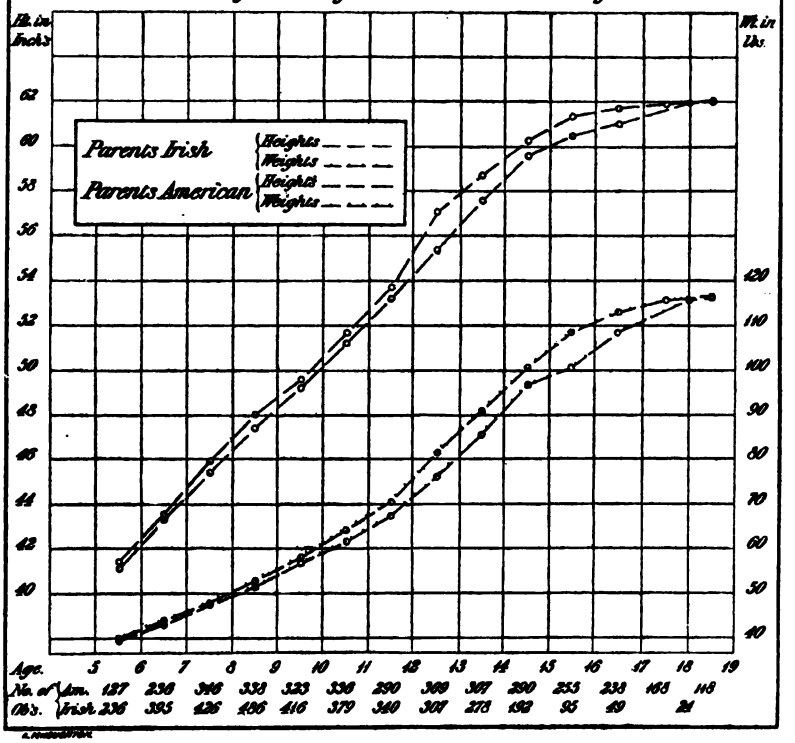


Plate VIII. *Showing comparative rate of growth of English Boys of the laboring and the non laboring classes.*

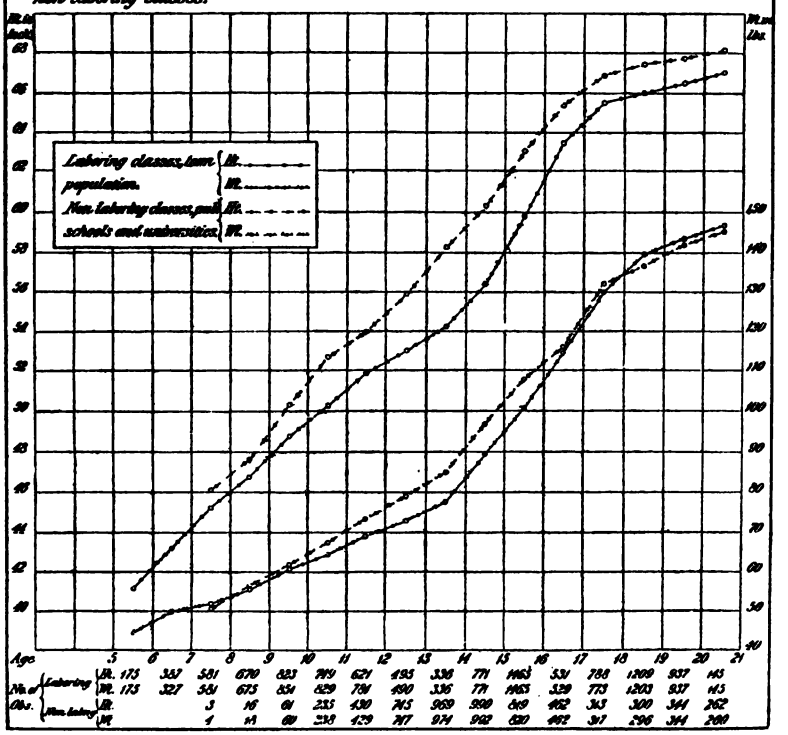


Plate IX. *Showing comparative rate of growth of English and American Boys.*

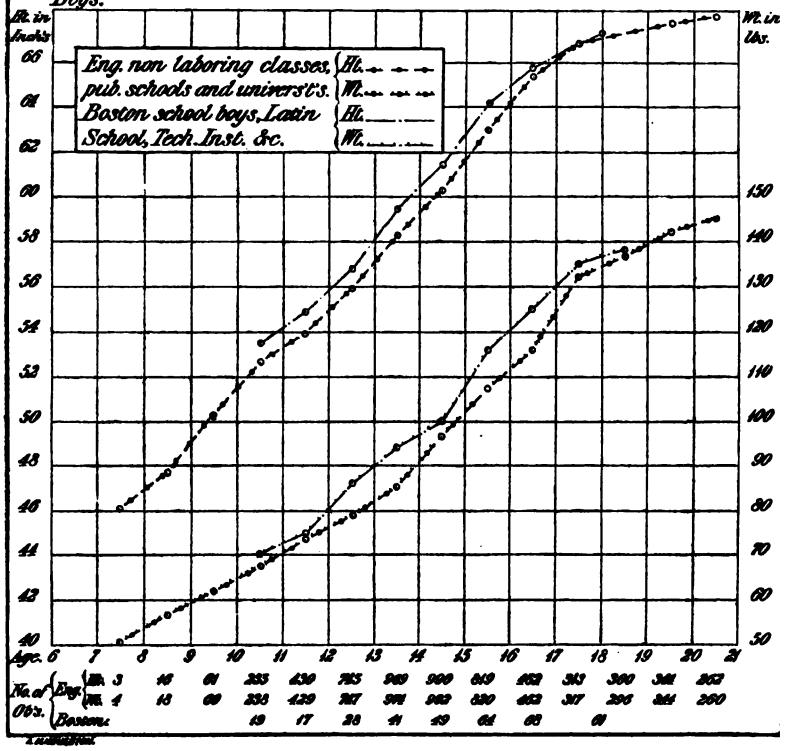


Plate X. *Showing comparative rate of growth of English and American Boys.*

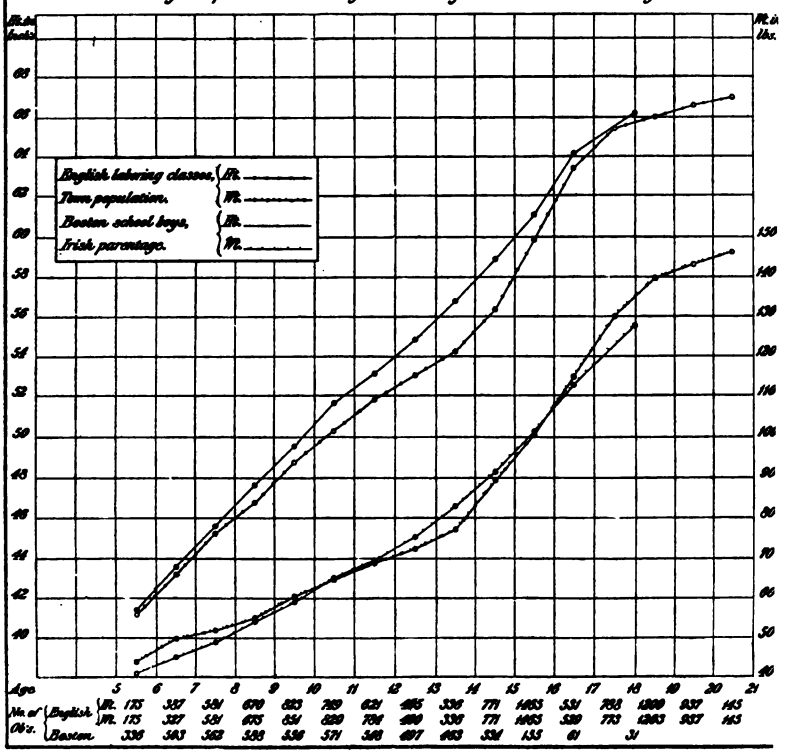


Plate XI. *Showing rate of growth of German boys in Germany and in America.*

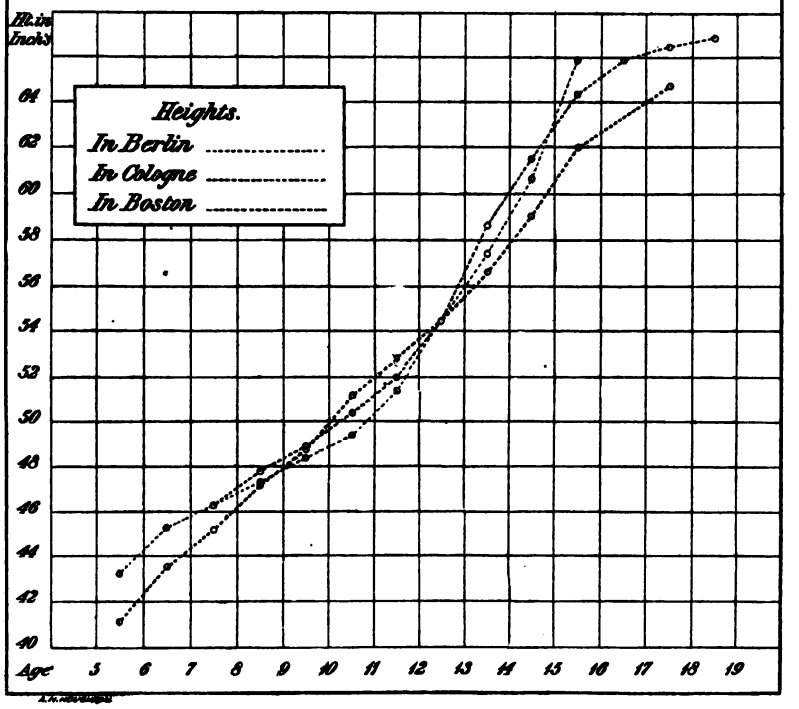


Plate XII. *Showing relation of height to weight in Boston school children.*

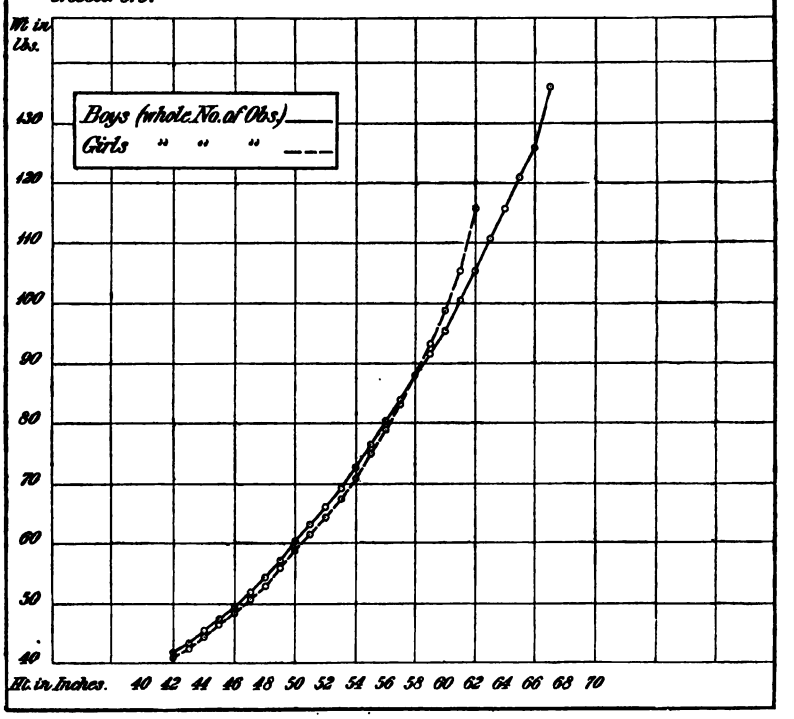


Plate XIII. *Showing relation of height to weight in Boston school boys.*

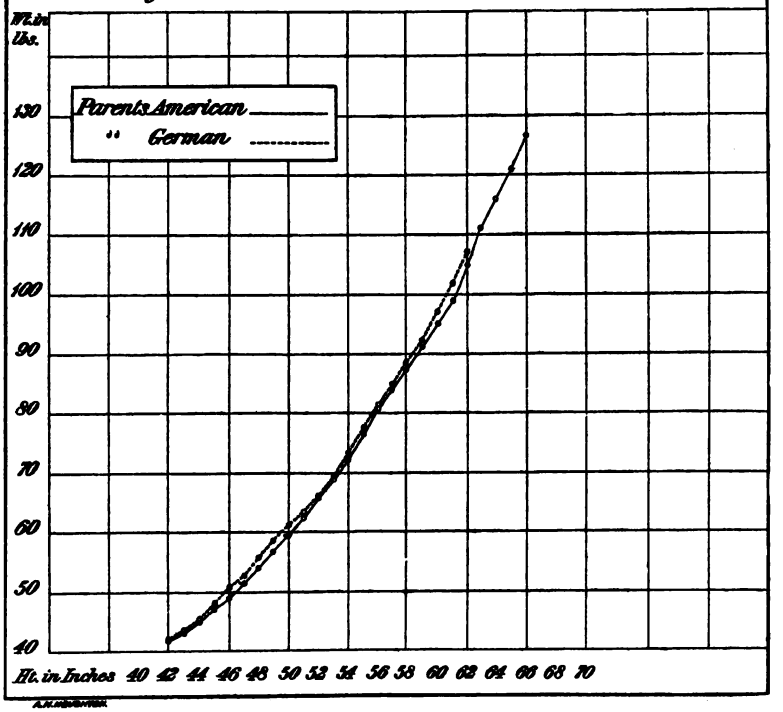


Plate XIV. *Showing relation of height to weight in English Boys.*

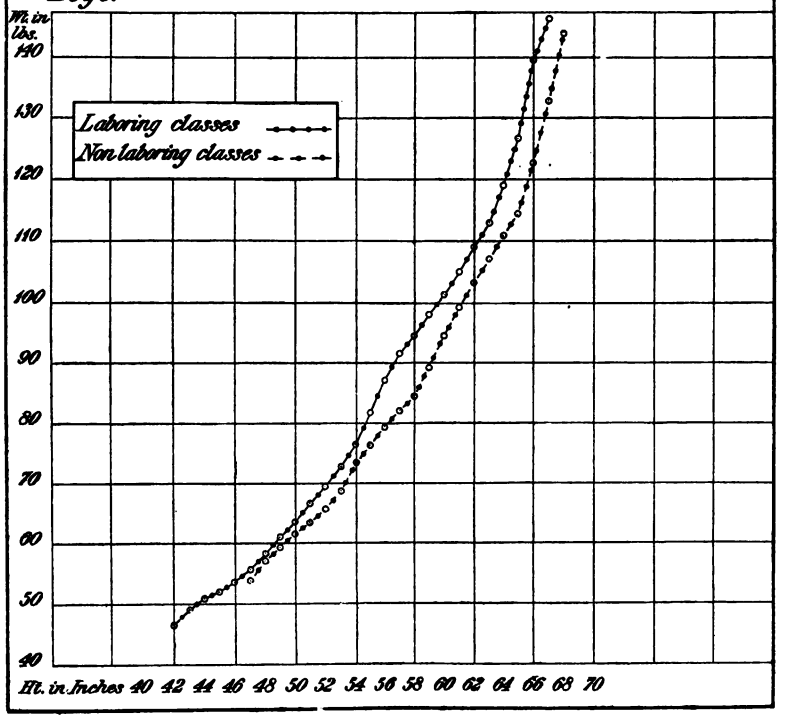
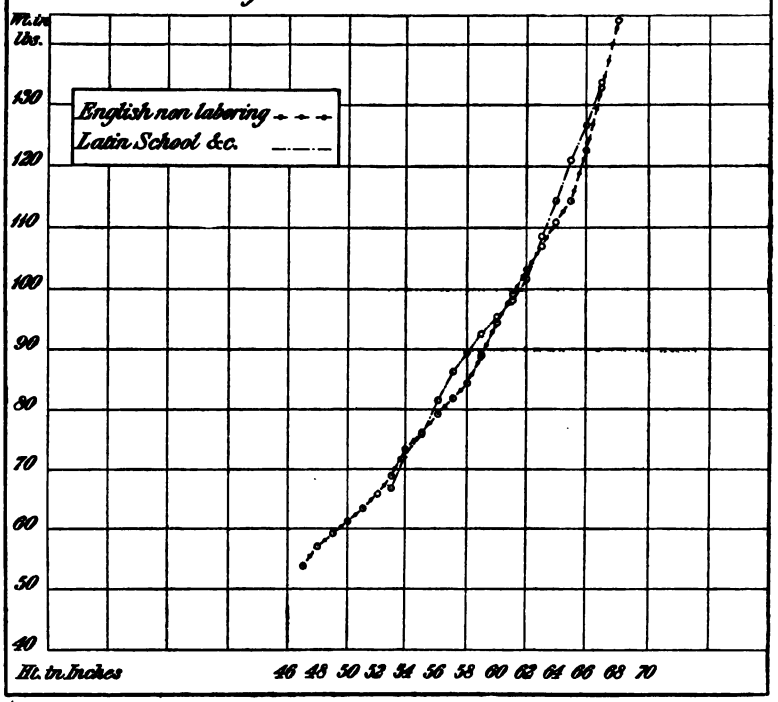


Plate XV. *Showing relation of height to weight in English and American Boys.*



tions,

ent.

09
48
17
36
95
54
19
08
78
1
78
55
55
5
9
31
6
55
03
34
7
7

tions, Irrespectiv

	14 Yrs.	
ent.	No.	Per cent
–	–	–
–	–	–
–	–	–
–	–	–
–	1	.11
–	6	.66
09	6	.66
48	17	1.87
17	12	1.32
36	31	3.41
05	46	5.06
54	49	5.39
19	68	7.48
08	75	8.25
78	101	11.12
11	105	11.56
8	127	13.98
55	95	10.46
55	62	6.82
15	47	5.17
9	34	3.74
31	11	1.21
6	7	.77
55	4	.44
03	3	.33
34	–	–
.7	1	.11
.7	–	–
–	–	–
–	–	–
–	–	–
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–	–	–
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–	–	–
–	–	–
–	–	–
–	–	–
	908	

Parentage.

INCHES.	5 Yrs.		14 Yrs.	
	No.	Per cent.	No.	Per ce
74, . .	–	–	–	–
73, . .	–	–	–	–
72, . .	–	–	–	–
71, . .	–	–	–	–
70, . .	–	–	–	–
69, . .	–	–	6	1.
68, . .	–	–	5	1.
67, . .	–	–	12	3.
66, . .	–	–	8	2.
65, . .	–	–	20	5.
64, . .	–	–	32	8.
63, . .	–	–	32	8.
62, . .	–	–	35	9.
61, . .	–	–	34	8.
60, . .	–	–	39	10.
59, . .	–	–	42	10.
58, . .	–	–	49	12.
57, . .	–	–	27	6.
56, . .	–	–	14	3.
55, . .	–	–	11	2.
54, . .	–	–	11	2.
53, . .	–	–	6	1.
52, . .	–	–	–	
51, . .	–	–	1	
50, . .	–	–	2	
49, . .	–	–	–	
48, . .	–	–	–	
47, . .	2	.99	–	
46, . .	1	.44	–	
45, . .	6	2.99	–	
44, . .	18	8.96	–	
43, . .	29	14.43	–	
42, . .	37	18.41	–	
41, . .	46	22.89	–	
40, . .	33	16.42	–	
39, . .	12	5.97	–	
38, . .	9	4.43	–	
37, . .	4	1.99	–	
36, . .	3	1.44	–	
35, . .	1	.44	–	
34, . .	–	–	–	
Totals, .	201		386	

ge..

rs.	15 Yrs.		16 Yrs.		17 Yrs.		18 Yrs.		POUNDS.
er cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.	
–	–	–	–	–	–	–	–	–	218 to 222
–	–	–	–	–	–	–	–	–	214 to 218
–	–	–	–	–	–	–	–	–	210 to 214
–	–	–	–	–	–	–	–	–	206 to 210
–	–	–	–	–	–	–	–	–	202 to 206
–	–	–	–	–	–	–	–	–	198 to 202
–	–	–	–	–	–	–	–	–	194 to 198
–	–	–	–	–	–	–	–	–	190 to 194
–	–	–	–	–	–	–	–	–	186 to 190
–	–	–	–	–	–	–	–	–	182 to 186
–	–	–	–	–	–	–	–	–	178 to 182
–	–	–	–	–	1	5.55	–	–	174 to 178
–	–	–	–	–	–	–	–	–	170 to 174
–	–	–	–	–	–	–	–	–	166 to 170
–	–	–	–	–	–	–	–	–	162 to 166
–	–	–	–	–	1	5.55	–	–	158 to 162
–	–	–	–	–	–	–	–	–	154 to 158
.52	–	–	1	2.04	–	–	–	–	150 to 154
1.04	–	–	–	–	–	–	–	–	146 to 150
–	1	1.05	–	–	1	5.55	–	–	142 to 146
.52	–	–	1	2.04	–	–	–	–	138 to 142
.52	2	2.10	1	2.04	–	–	–	–	134 to 138
–	2	4.21	2	4.08	–	–	–	–	130 to 134
1.04	–	–	2	4.08	1	5.55	–	–	126 to 130
1.56	4	4.21	1	2.04	2	11.11	–	–	122 to 126
1.56	–	–	5	10.20	–	–	–	–	118 to 122
3.12	3	3.16	3	6.12	–	–	–	–	114 to 118
6.25	8	8.42	3	6.12	4	22.22	2	33.33	110 to 114
8.85	8	8.42	5	10.20	5	27.77	1	16.66	106 to 110
8.33	15	15.80	5	10.20	2	11.11	1	16.66	102 to 106
10.93	13	13.68	10	20.41	1	5.55	1	16.66	98 to 102
10.93	9	9.47	5	10.20	–	–	1	16.66	94 to 98
11.45	9	9.47	2	4.08	–	–	–	–	90 to 94
8.33	6	6.31	1	2.04	–	–	–	–	86 to 90
6.77	8	8.42	1	2.04	–	–	–	–	82 to 86
12.00	2	2.10	–	–	–	–	–	–	78 to 82
1.56	2	2.10	1	2.04	–	–	–	–	74 to 78
1.56	3	3.16	–	–	–	–	–	–	70 to 74
1.56	–	–	–	–	–	–	–	–	66 to 70
1.04	–	–	–	–	–	–	–	–	62 to 66
.52	–	–	–	–	–	–	–	–	58 to 62
–	–	–	–	–	–	–	–	–	54 to 58
–	–	–	–	–	–	–	–	–	50 to 54
–	–	–	–	–	–	–	–	–	46 to 5[illegible]
–	–	–	–	–	–	–	–	–	42 [illegible]
–	–	–	–	–	–	–	–	–	38
–	–	–	–	–	–	–	–	–	34 to [illegible]
–	–	–	–	–	–	–	–	–	30 to 34
	95		49		18		6		